A CAHNERS PUBLICATION
INTERNATIONAL EDITION
JANUARY 8, 1987

EDN

Statistical techniques aid datacomm testing

Low-noise designs enhance high-speed digitizers

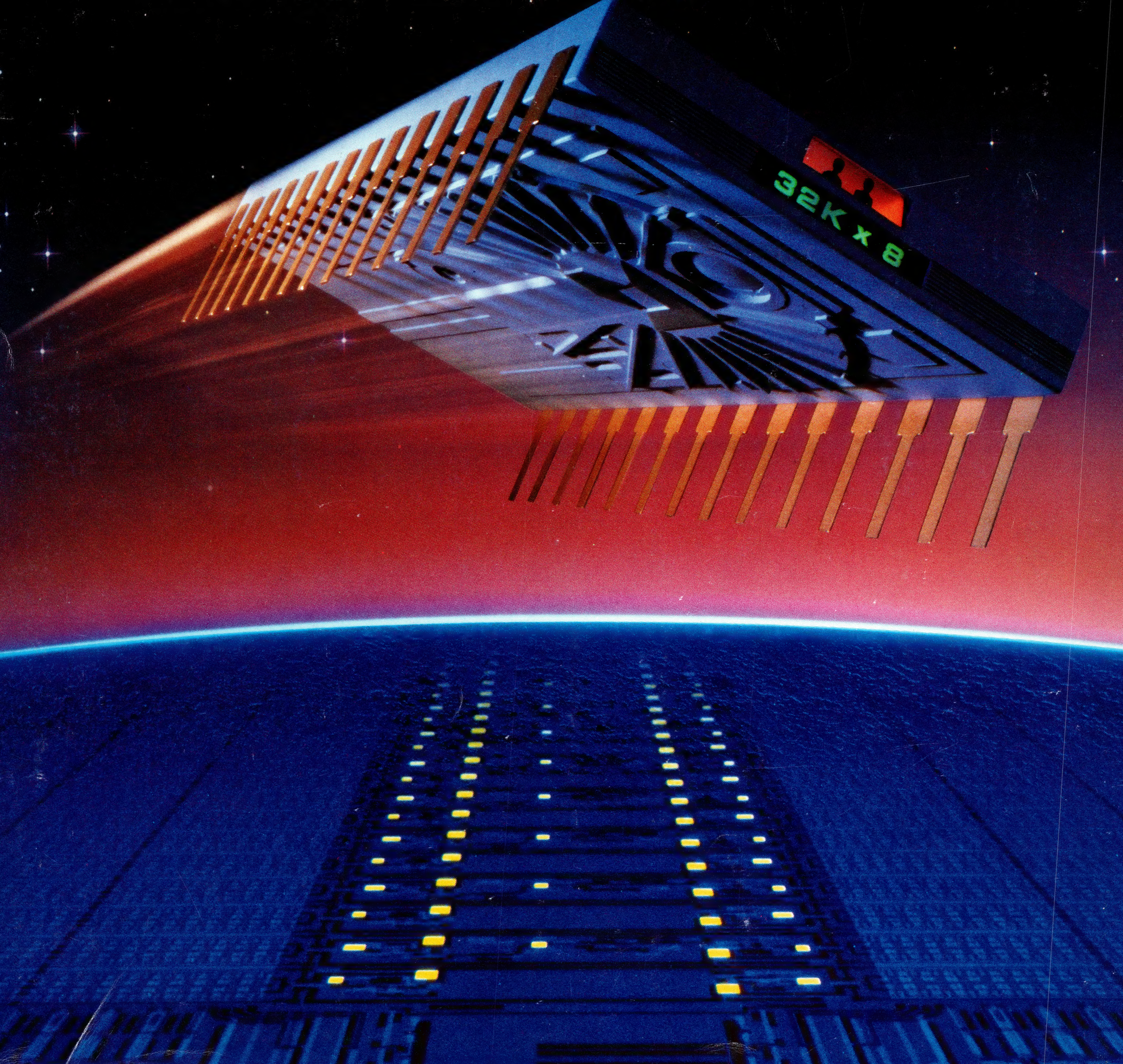
Intelligent Peripheral Interface standard

3 APR REC'D

Stepper motors

ELECTRONIC TECHNOLOGY FOR ENGINEERS AND ENGINEERING MANAGERS

Static RAMs speed toward niche applications



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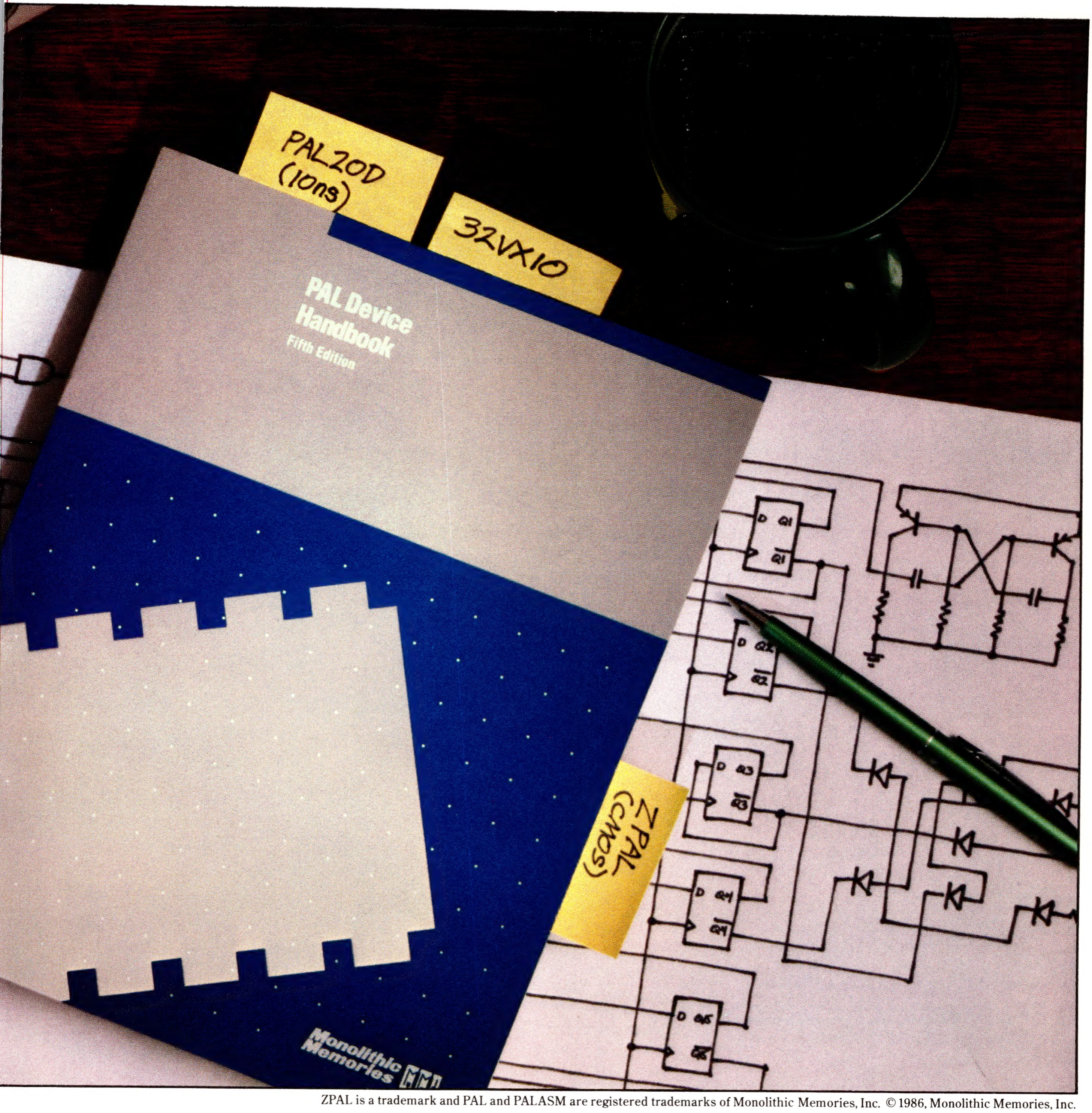

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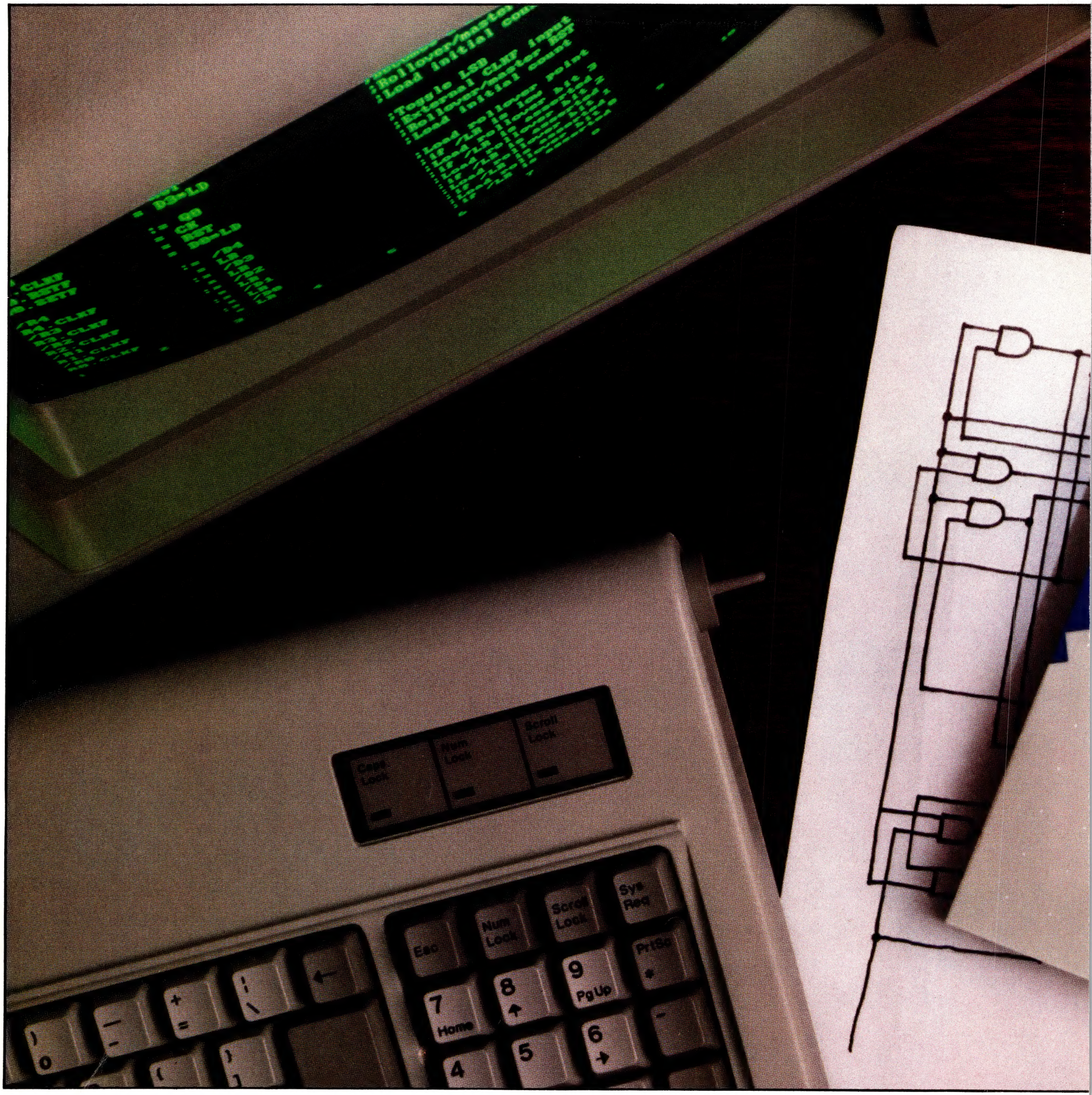
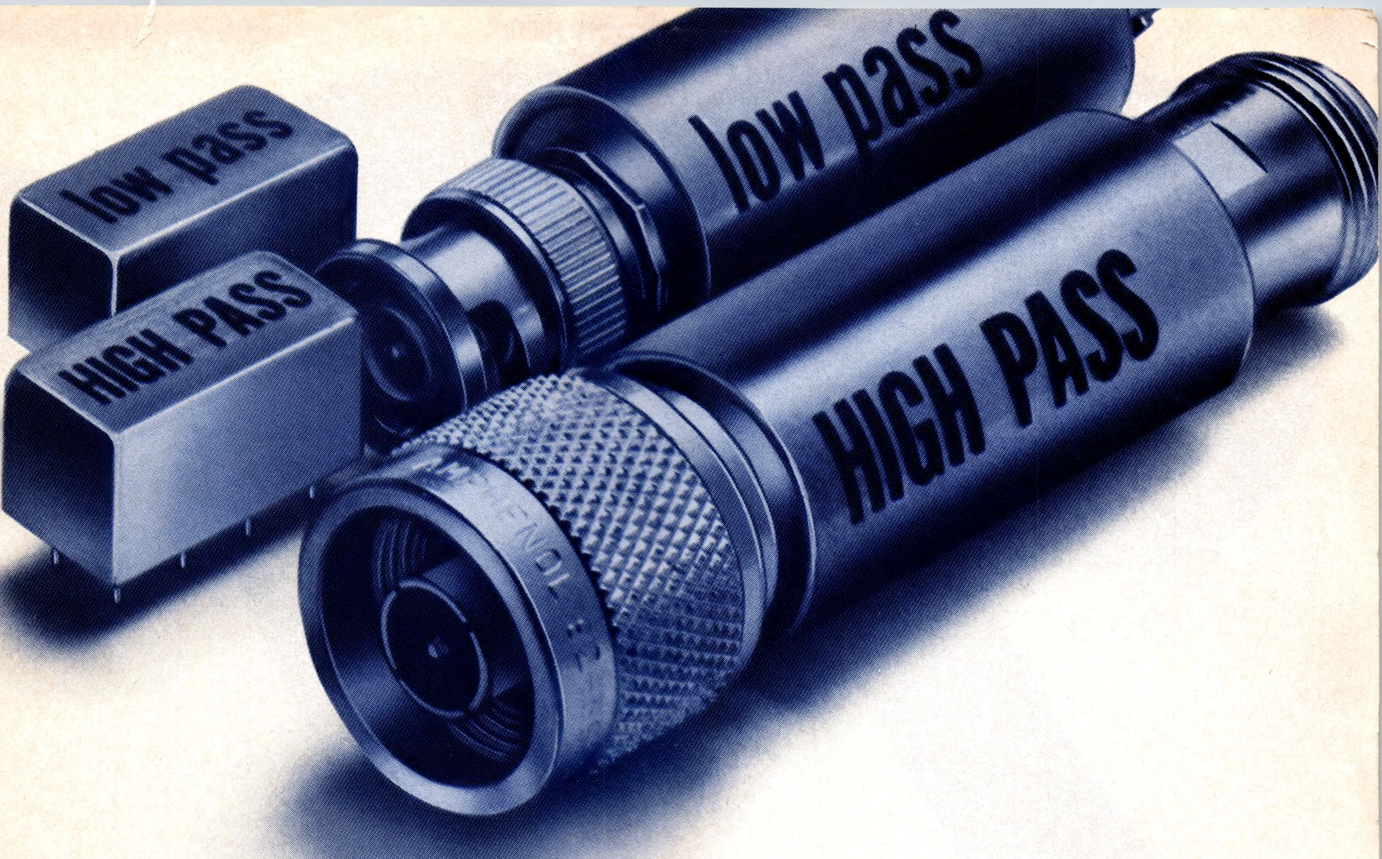


Save your system.



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LOW PASS **Model** ***LP–**	**10.7**	**50**	**70**	**100**	**150**	**200**	**300**	**450**	**550**	**600**	**750**	**850**	**1000**
Min. Pass Band (MHz) DC to	10.7	48	60	98	140	190	270	400	520	580	700	780	900
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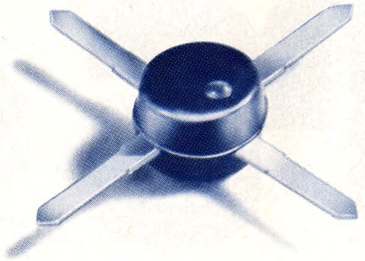

dc to 2000 MHz amplifier series

SPECIFICATIONS

Model	Frequency MHz	Gain, dB (min.)	Max. Power dBm (typ)	NF dB (typ)	Price $ Ea.	Qty.
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MAR-3	DC-2000	8	+8	6.0	1.70	(25)
MAR-4	DC-1000	7	+11	7.0	1.90	(25)
MAR-7	DC-2000	8.5	+4	5.0	1.90	(25)
MAR-8	DC-1000	21	+10	3.5	2.20	(25)

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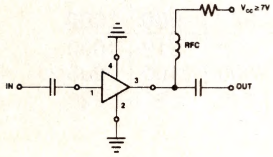
80 × 50	10%	X7R	2200, 4700, 6800, 10,000 pf
120 × 60	10%	X7R	.022, .047, .068, .1μf

* MINIMUM ORDER 50 PER VALUE

Typical Biasing Configuration



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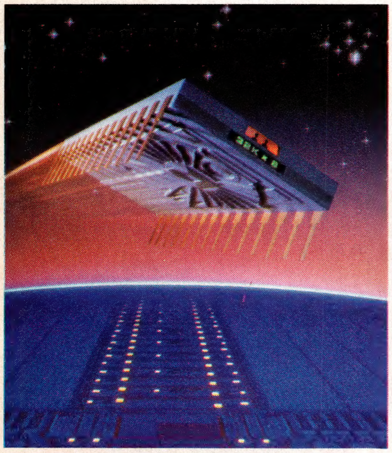
Volume 32, Number 1

EDN

January 8, 1987

ELECTRONIC TECHNOLOGY FOR ENGINEERS AND ENGINEERING MANAGERS



***On the cover:** Static RAMs are now achieving impressive speeds and densities; moreover, many are offering application-specific features. See pg 128. (Photo courtesy Advanced Micro Devices)*

DESIGN FEATURES

Special Report: Static RAMs 128

Innovation is driving the market for static RAMs, providing designers with an assortment of memory devices that sport a variety of features—including speed/density combinations that challenge dynamic-RAM performance. Continuing improvements in fabrication processes promise even further advances in important static-RAM specs.—*J D Mosley, Regional Editor*

Use statistics to test communications systems efficiently 143

Unless you use statistics, it's virtually impossible to determine just how many measurements are required for an accurate test of a system like a telecommunications receiver. In fact, you're probably testing your systems more than you have to.—*R F Cobb, Harris Corp*

Instrumentation amp suits wide range of circuit designs 157

The latest monolithic instrumentation amplifiers (IAs) ease the design of a variety of high-input-impedance circuits. Data acquisition, overvoltage protection, current sensing, the driving of current loops, programmable gain amplification—all of these applications can benefit from IAs' improved performance specs.—*Rod Burt, Burr-Brown Corp*

Interface your PC to the Multibus 167

Even if you don't have a full set of development software for your Multibus system, you can still test your Multibus products: A hardware interface between an IBM PC and a Multibus system will let you run your Multibus test programs on the IBM PC.—*William H Robertson, KLA Instruments Corp*

Low-power op amp delivers precision at low signal levels 185

Single-supply and battery-powered designs often have high signal impedances and low signal voltages, so they demand low input currents and precision amplification. To obtain precise performance in your low-power circuits, you can use an op amp that draws 15 μA of quiescent current.—*Derek F Bowers, Art Kapoor, and Andrew Jenkins, Precision Monolithics Inc*

Continued on page 7

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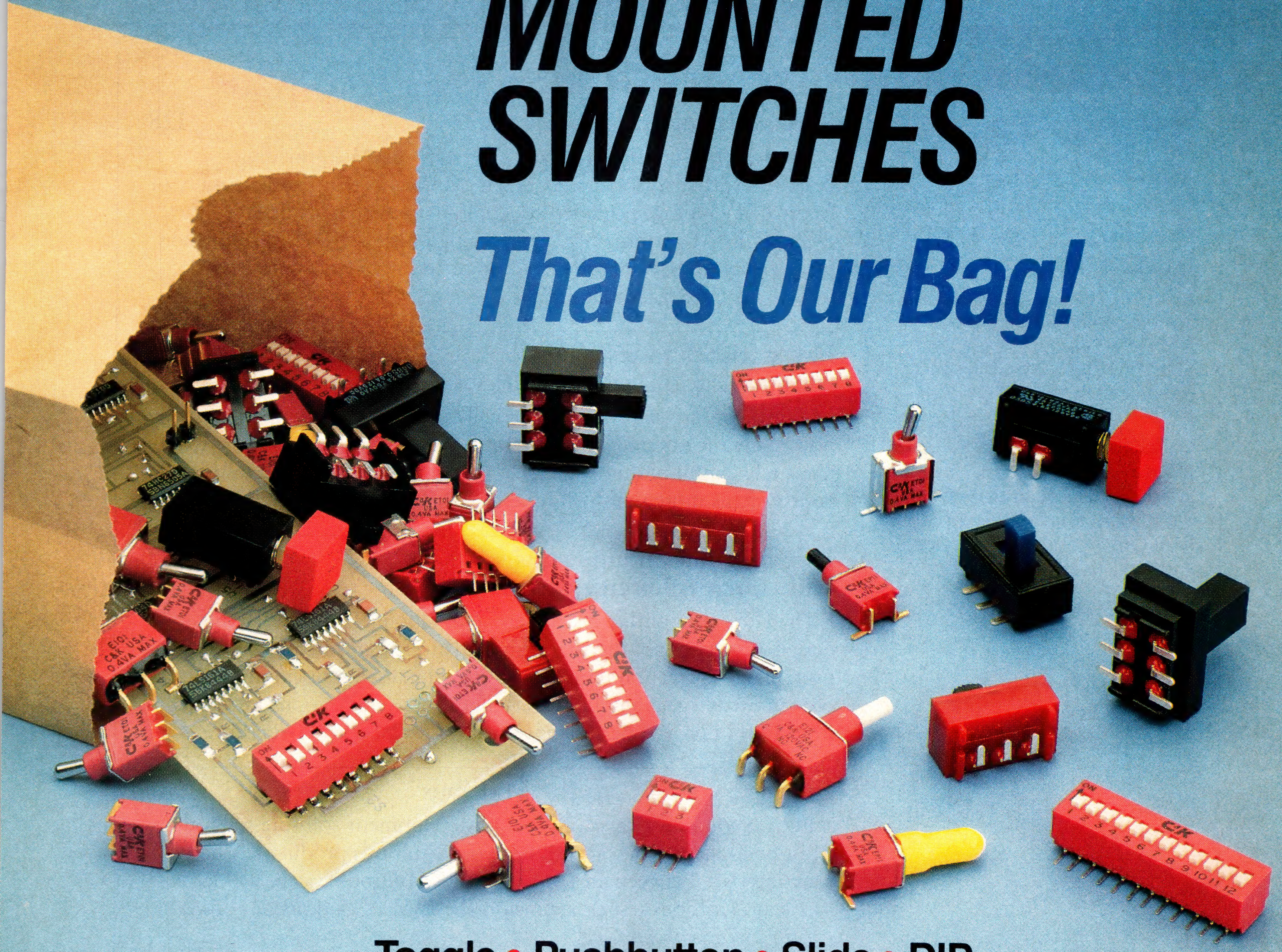

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Continued from page 5

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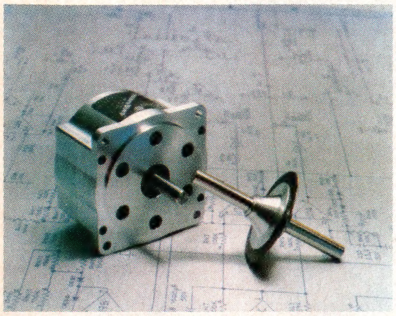

Thanks to improved microstepping techniques, *stepper motors are now competing with servo systems in high-performance applications (pg 85).*

TECHNOLOGY UPDATE

Design steps improve effective resolution of digitizing scopes, waveform digitizers 61

High-performance oscilloscopes and waveform digitizers are incorporating low-noise designs and other techniques, such as averaging and lowpass filtering, to increase their vertical resolution.—*Chris Everett, Regional Editor*

Modern stepper-motor systems provide precise position control and resolution 85

In addition to an inherent ability to accurately control position, today's stepper motors are taking advantage of new microstepping-drive techniques and the resulting higher resolution to find increased use in computer-peripheral and industrial-robotic applications.—*Tom Ormond, Senior Editor*

Intelligent Peripheral Interface standard permits data-transfer rates of 10M bytes/sec 105

High-end peripheral products, especially Winchester disk drives, have outgrown such I/O interface standards as the Storage Module Device and Enhanced Small Device Interface standards. The Intelligent Peripheral Interface is a high-performance alternative. —*Maury Wright, Regional Editor*

PRODUCT UPDATE

16-bit multiplying DAC **117**
Repeaterless fiber-optic links **118**

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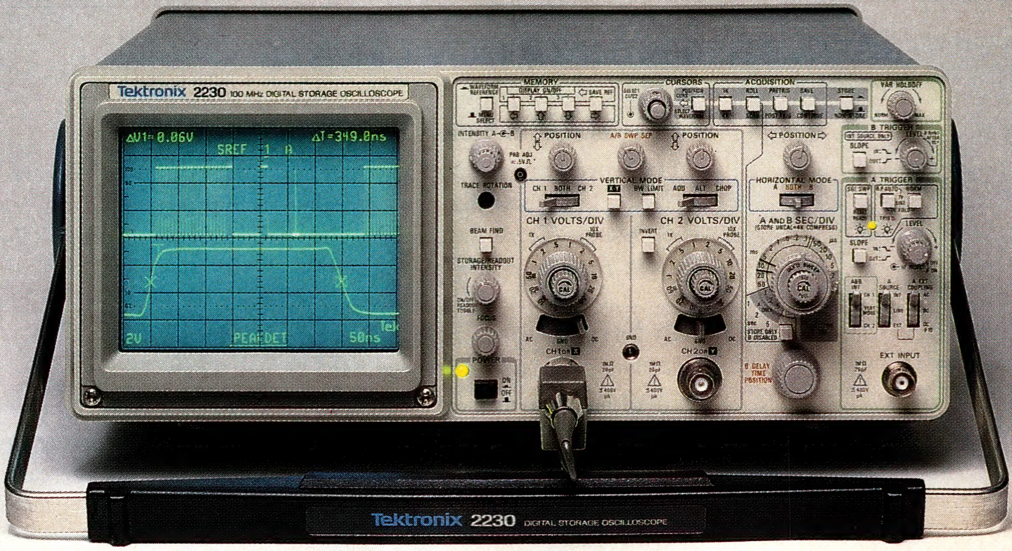
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Tektronix 2230 DIGITAL STORAGE OSCILLOSCOPE

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Record Length	4K/1K (selectable)	4K
Save Reference Memory	One, 4K Three, 1K	One, 4K
Vertical Resolution	8 bits 10 bits (AVG mode) 12 bits (AVG mode over bus)	8 bits
CRT Readout	Yes	No
Cursor Measurements	Yes (storage mode)	No
GPIB/RS-232-C Options	Yes ($850)	Yes ($550)
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Before the US gets back into space, we must develop new launch vehicles and find an inspirational champion of space exploration.

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The whistle blower's burden: Public approval, corporate exile.
—Deborah Asbrand, Associate Editor

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Electromechanical-switch market draws foreign entries . . . Fiber-optic communication threatens switch market.

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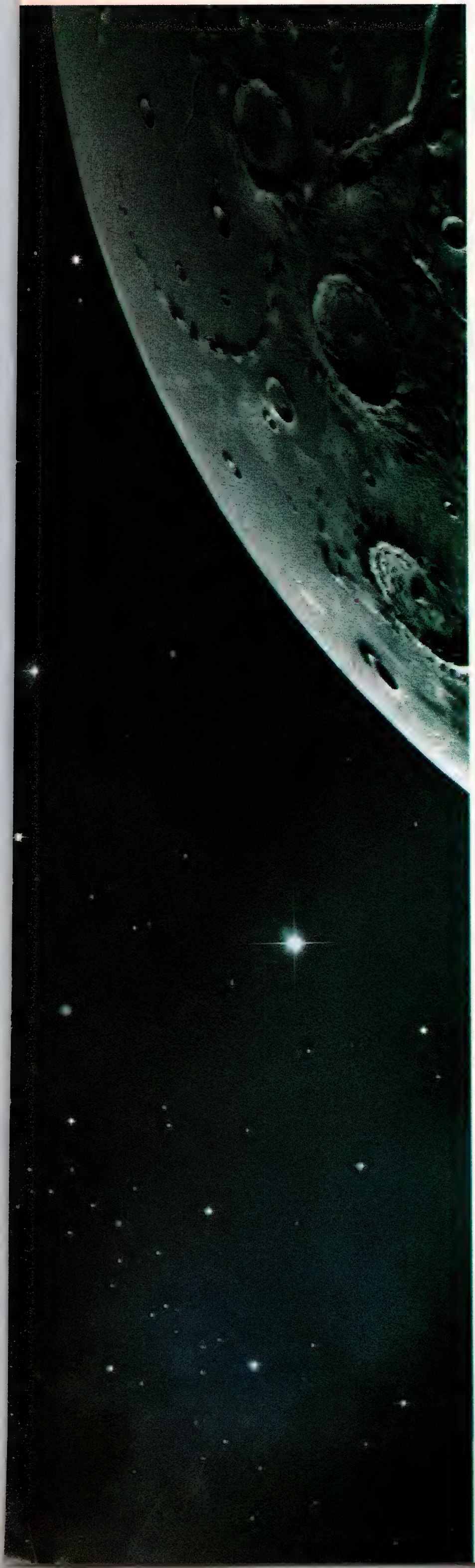

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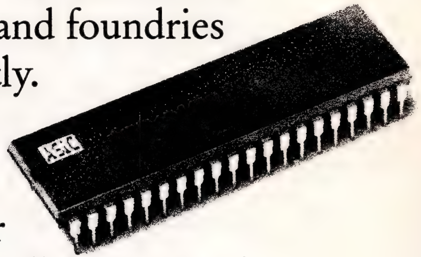

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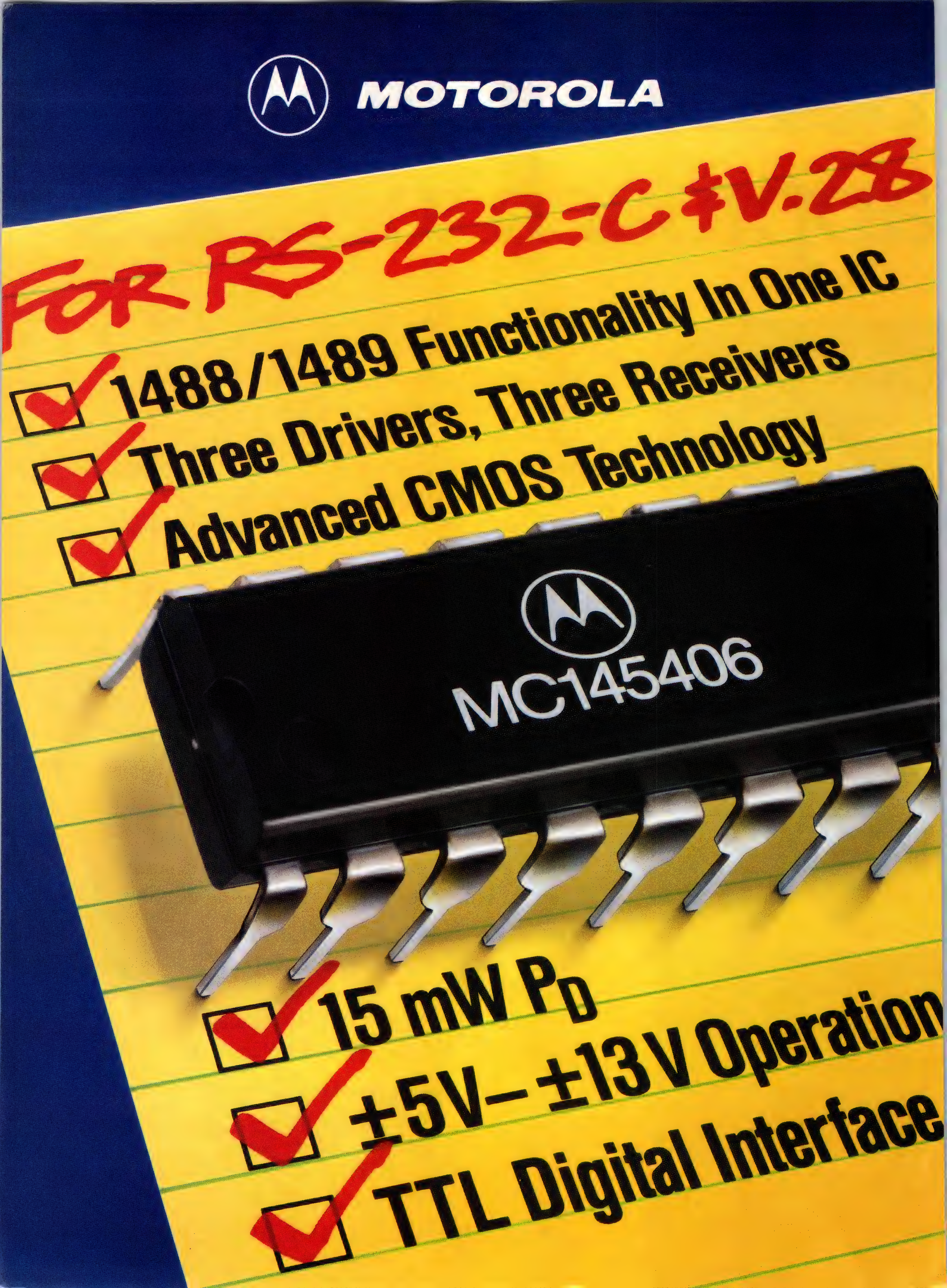
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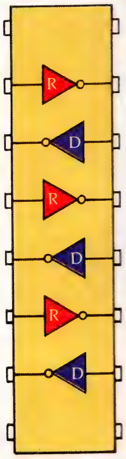

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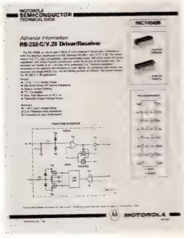

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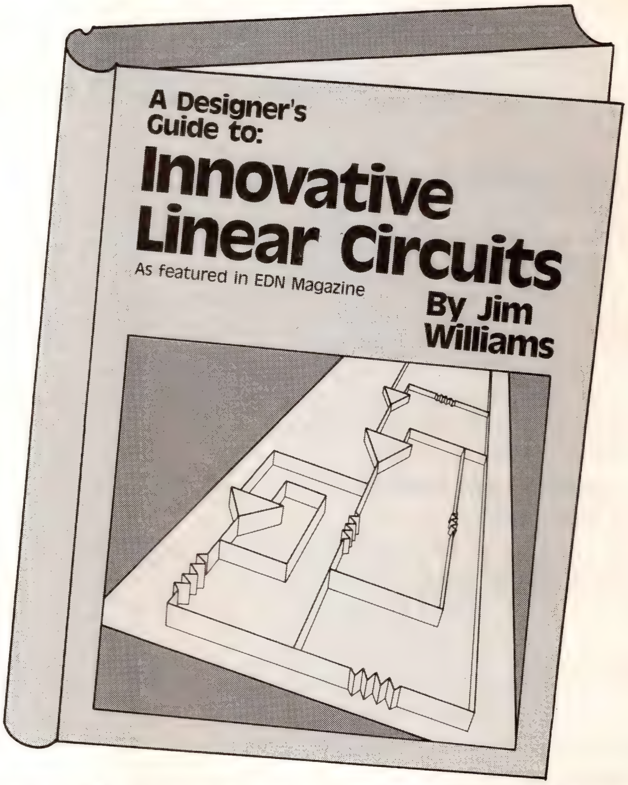

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```
STATE PC        DISASSEMBLY
TRIG  000430 MOVEA.W #4007,A1     68000T
00004 000434 MOVE.B  #0098,D1              S/U
00006 000438 MOVE.B  D1,(A1)
      004007<98                            S
00007 00043A RTS                           S
      PC:FFC0B0>00000400                   S
00012 000400 JSR     0430
      PC:FFC0B0<00000404                   S
00014 000430 MOVEA.W #4007,A1
00018 000434 MOVE.B  #0098,D1              S
00020 000438 MOVE.B  D1,(A1)
      004007<98
00021 00043A RTS                           S
      PC:FFC0B0>00000400                   S
f1=Pos. Cursor f2=Spd: Slow  f3=Cycles: on S
```

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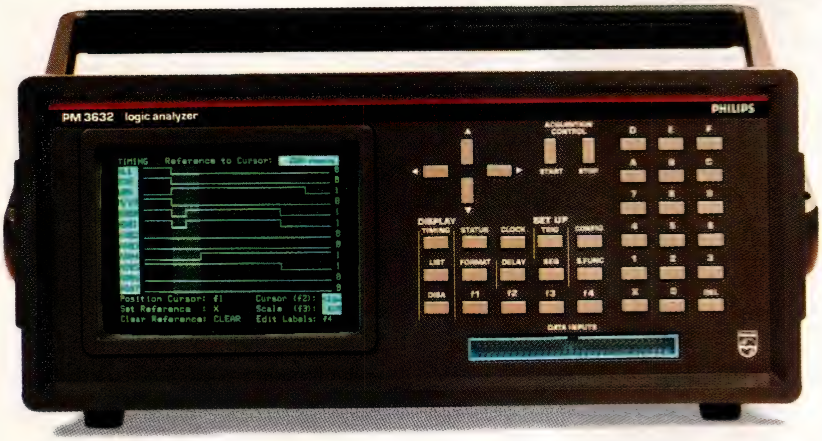

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CIRCLE NO 15

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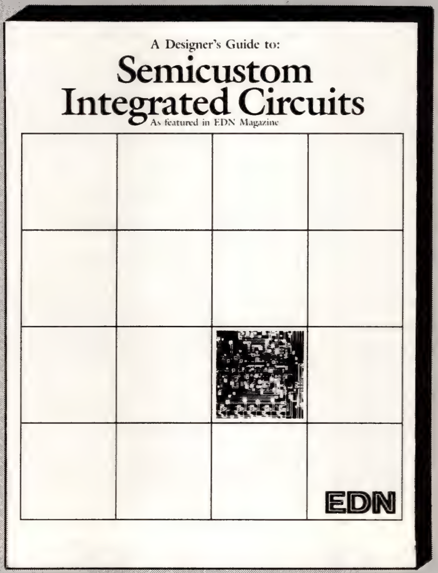

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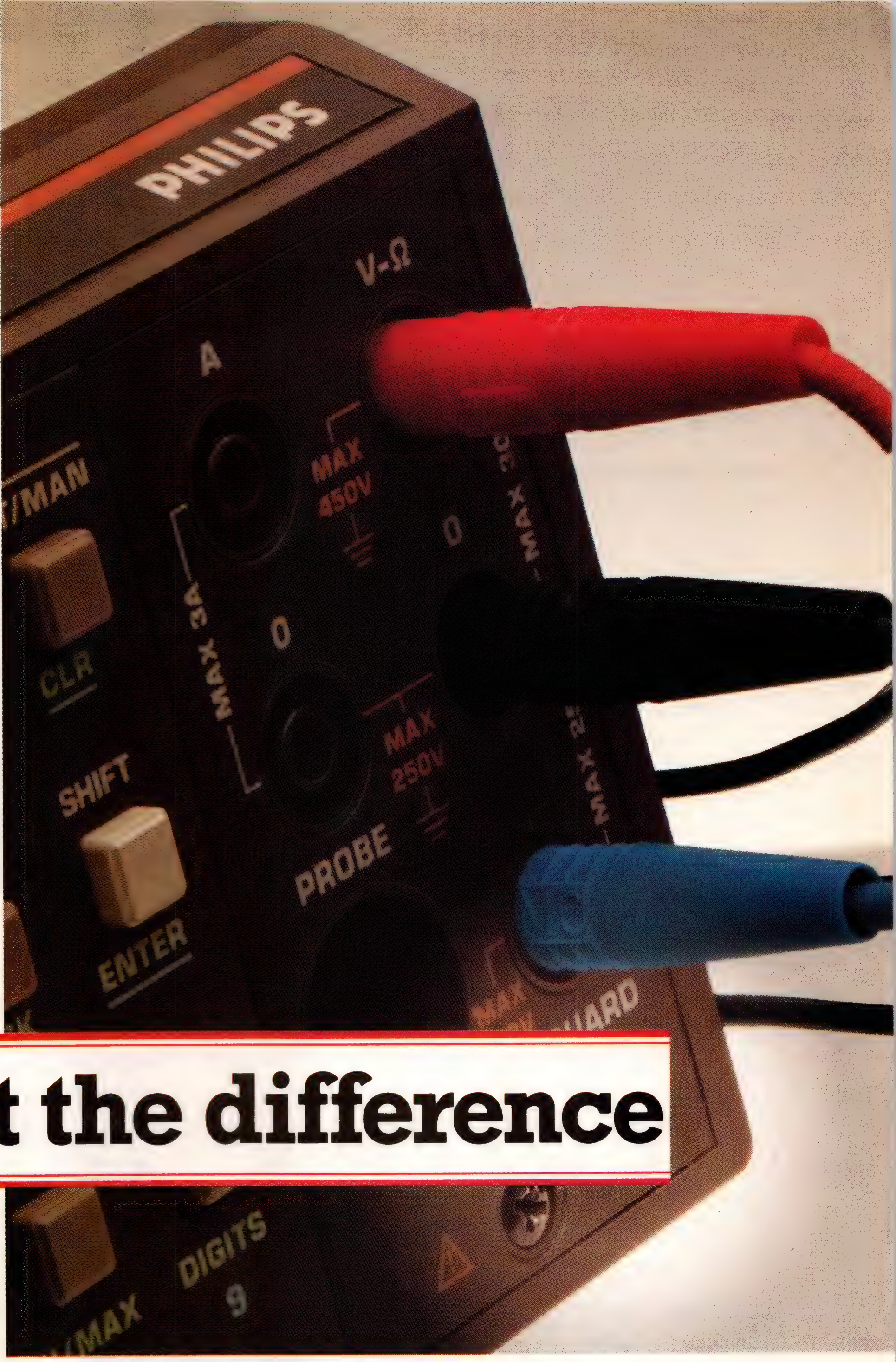

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Test & Measurement

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CIRCLE NO 16

The µPD612X Series

Get Going with Remote Control

Remote control is the name of the game when it comes to quick and efficient manipulation of audio-visual equipment and other home or office appliances. And NEC's new CMOS-based µPD6124/5/6 Series is the infrared remote control transmitter that combines programmability with small packaging and low power consumption. Excellent performance stems from a 1024 x 10 bits program memory, 32 x 4 bits data memory, and a large instruction set. A standby mode plus low operating voltage reduces battery design to a minor detail.

TYPE	KEYS	PACKAGE
µPD 6124	32	20 PIN MINIFLAT
µPD 6125	64	24 PIN MINIFLAT OR SLIM DIP
µPD 6126	96	28 PIN MINIFLAT

The µPD612X Series features 32, 64 or 96 key inputs. All remote control commands and functions are programmable and the transmission format can be customized. The operating frequency is either 38 or 58 KHz.

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UK: Milton Keyes 09 08/69 11 33, Telex 777 565

NEC

CIRCLE NO 17

NEWS BREAKS

EDITED BY JOAN MORROW

SYSTEM MEASURES PHASE NOISE OVER 5 MHz TO 18 GHz

The HP 3048A phase-noise measurement system measures random-noise amplitude and discrete, spurious signals on carriers ranging from 5 MHz to 1.3 GHz. Over a 0.01-Hz to 1-MHz frequency offset range, it measures to within 2 dB; above a 1-MHz frequency offset, it measures to within 4 dB. An optional $2200 microwave phase detector extends the operating range of the system to 18 GHz. An HP 98580A desktop computer ($9625) controls the phase-noise measurement system, automatically configures the integral frequency-synthesized signal generator, calibrates the overall system with a user-selected calibration routine, applies corrections to the resulting data, and then formats and displays the results. Using the systems analysis tools, you can determine the frequency and amplitude of noise spurs or plot the relative amplitude change of noise vs offset frequency. From Hewlett-Packard (Palo Alto, CA), the HP 3048A costs $31,500.—Steven H Leibson

SPEECH-RECOGNITION SYSTEM HAS REAL-TIME 1000-WORD CAPABILITY

A 99.3% accurate, software-based speech-recognition system from Cherry Electrical Products (Waukegan, IL, (312) 360-3500) gives you real-time performance with a 1000-word vocabulary (when used with an 8-MHz IBM PC/AT or compatible computer). To train the system, you repeat each word four times, producing a pattern that is a combination of the four repetitions. Unlike hardware-based systems, the training repetitions do not reduce the total vocabulary capacity—only the combinatorial word pattern is stored in the system. Software leads you through the process of setting up the system, and the applications manual helps you configure your system. Priced at $756 (100), the system includes a headset microphone, an expansion card for your computer, software, and overlays for several popular programs.—J D Mosley

16-MHz 80386-BASED PC SURPASSES DESKPRO'S PERFORMANCE

A personal computer called the 386^{16} from PC's Limited (Austin, TX, (512) 339-6800) operates twice as fast as Compaq's DeskPro 386 in conventional memory-read benchmarks, 47% faster in NOP executions, 21% faster on integer-add from memory, and 26% faster in floating-point calculations. The computer accomplishes this performance by using fast static RAM instead of dynamic RAM, thus enabling the system to provide zero-wait-state operation for the currently available 16-MHz 80386 μP and for a future 24-MHz 80386. The computer also uses VLSI technology to reduce the motherboard chip count to less than 30. An alphanumeric LED called a SmartVu displays μP speed and diagnostic checks. The machine will be available in the first quarter and will carry a mid-$4000 price tag. —J D Mosley

16-BIT SELF-CALIBRATING ADC HAS 16-μSEC CONVERSION TIME

Offering a true 16-bit digital representation of a bipolar or unipolar analog signal in 16 μsec at sampling rates reaching 50 kHz, the CS5016 A/D converter also features a self-calibration circuit that ensures maximum nonlinearity of 0.001% and no missing codes at 16 bits. Offset and full-scale errors remain within 3/4 LSB, eliminating the need for manual calibration. This CMOS IC from Crystal Semiconductor (Austin, TX, (512) 445-7222) dissipates 150 mW and features an on-chip μP interface. A 14-bit version, the CS5014, has a maximum nonlinearity of 0.003% at throughput rates reaching 50 kHz. When they become available at the end of the first quarter, the CS5016 will cost $140, and the CS5014 will cost $45 (100).—J D Mosley

NEWS BREAKS

DYNAMIC-RAM CONTROLLERS SUPPORT 256k- TO 4M-BIT CHIPS

A family of CMOS dynamic-RAM controller/driver ICs provides support for 256k-, 1M-, and 4M-bit memory chips. The National Semiconductor Corp (Santa Clara, CA, (408) 721-5000) controller/driver family includes the DP8422V, DP8421V, and DP8420V for 4M-, 1M-, and 256k-bit dynamic RAMs, respectively. Members of the product line provide a single-chip interface between all widely used μPs and dynamic RAMs. You can program the controllers' memory-access mode for burst/nibble, page, and static column memory-access modes. The chips also support interleaving of memory access to different memory banks to eliminate delays caused by precharge time. The controllers automatically perform either staggered or burst refresh transparent to the system. The chips cost $17 to $25 (1000).—Maury Wright

PLASMA DISPLAY USES CHIP-ON-GLASS TO SUPPORT 192×88 PIXELS

Chip-on-glass construction allows Dale Electronics (Columbus, NB) to build the low-profile APD-192G088 dot-matrix plasma display panel with 192 columns×88 rows of pixels. The 0.350-in.-thick panel features a 7.66×3.5-in. viewing area with a 120° conical viewing angle. The company claims the construction increases the $435 (100) panel's reliability and reduces assembly costs.—Steven H Leibson

LINE RECEIVER HAS LOWPASS FILTER FOR ADDED NOISE IMMUNITY

The SN75146 dual differential line receiver from Texas Instruments (Dallas, TX) incorporates a 5-MHz lowpass filter to reject noise picked up by long transmission lines. The device is intended for applications with data rates below 355 kHz and is compatible with the differential RS-422A and single-ended RS-423A standards. You can add a bias resistor to make the SN75146 compatible with single-ended RS-232C interfaces. The IC costs $1.17 (100).—Steven H Leibson

1.2-μm PROCESS AVAILABLE FOR GATE ARRAYS AND STANDARD CELLS

Thomson-Mostek (Carrollton, TX, (214) 466-6346) now offers a double-level metal 1.2-μm process for ASIC designs. Gate arrays specing subnanosecond delays are available in functional densities from 1000 gates with 56 I/Os to 10,000 gates with 192 I/Os. Housed in DIP, chip-carrier, and PGA packages, these gate arrays have submicron effective electrical channel lengths and operate with a typical gate delay of 0.9 nsec for a 2-input gate driving a fan-out of 2. The 1.2-μm standard-cell family consists of 120 fixed-height cells including compilable 75-MHz counters and registers, 40-nsec static RAMs, ROMs, FIFO buffers, and PLDs.—J D Mosley

PROGRAMMABLE SWITCH GAINS MICROWAVE MODULES

Hewlett-Packard Co (Palo Alto, CA) has added three switch modules to the line of plug-ins available for its HP 3488A programmable switch/control unit. The $2200 HP 44476A microwave switch module offers three 50Ω coaxial switch channels with a frequency range of dc to 18 GHz and 90-db isolation. The $400 HP 44476B module accepts two HP 3331xx coaxial switches, which are available in 3-, 4-, and 5-port versions. The 7-channel, $400 HP 44477A form-C relay module drives the company's HP 8594/5/6 and 33300 Series programmable step attenuators and also can drive remote microwave relays.—Steven H Leibson

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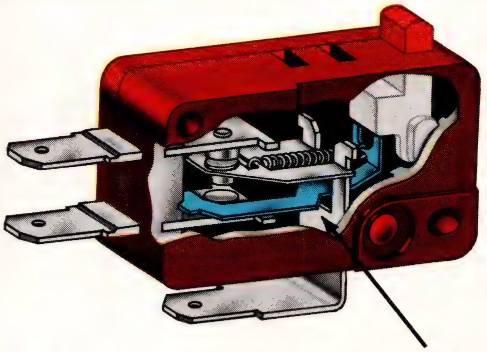

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CIRCLE NO 18

NEWS BREAKS: INTERNATIONAL

1-CHIP DEVICE INTEGRATES 16-BIT-μP PERIPHERAL FUNCTIONS

The MB89391, a chip produced from the joint efforts of Fujitsu Ltd and Fujitsu VLSI Inc, is a single-chip CMOS device that integrates the peripheral functions of the MBL8086 16-bit microprocessor. It incorporates a clock generator, a bus controller, an interrupt controller, a DMA controller, and a timer. The device can handle as many as eight interrupts or a maximum of 64 if you attach an external controller. It comes in a 100-pin quad-flat package and costs ¥2400 ($15.48) for samples.

3½-IN. FLOPPY-DISK DRIVE HAS 2M-BYTE CAPACITY

Mitsubishi Electric Corp has introduced a 3½-in. floppy-disk drive with a maximum memory capacity of 2M bytes. The 32-mm-thick drive comes in a 1M-byte version, which is being sampled at ¥50,000 ($322.58); the 1.6M- and 2M-byte units cost $387. The drive features an access time of 3 msec and is housed in a shock- and vibration-proof structure.

TOSHIBA BECOMES JAPAN'S SECOND LARGEST SEMICONDUCTOR PRODUCER

Toshiba Corp has outpaced Hitachi Ltd to become the second largest semiconductor company in Japan; Nippon Electric still leads the field. Toshiba acquired the slim margin during the first half of fiscal 1986, in which it recorded a 10% gain to reach ¥205 billion ($1.3 billion), while Hitachi had a 15% decrease for a total of $1.25 billion. Toshiba cites a 10% increase in memory production and a 40% increase in exports of linear ICs and discrete devices to Asian markets as reasons for its growth.

Meanwhile, Hitachi will reduce its capital investments in the semiconductor area and its R&D expenditures for the remainder of fiscal 1986. Furthermore, approximately 500 employees from low-profit departments will be transferred to the computer-software-development department, and the company will cut managerial salaries by 5 to 10%.

MITSUBISHI, 12 OTHER COMPANIES TO WORK ON SPACE LABORATORY

Mitsubishi Electric Corp has become the prime contractor for the Japanese "Free Flyer" project, a 13-company venture that will develop a 3-ton space laboratory. Scheduled for launch in fiscal 1992, the entire structure will house eight laboratories for conducting experiments on semiconductors and for research into new materials and biotechnology. The program, which is estimated to cost ¥30 billion ($194 million), is being promoted by the Ministry of International Trade and Industry, the Education Ministry, and the Science and Technology Agency.

Other companies involved in this effort include Nissan Motors (for the frame structure), Toshiba (for the power-supply system), Nippon Electric (for the communication equipment and solar-cell paddle), Fujitsu (for the ground-control system), and Hitachi (for the bioengineering systems).

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T9-1	5950-01-105-8153
TMO9-1A	5950-01-098-6315
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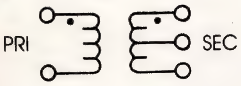
A* 	T	T1-1T	1	.05-200	.05-200	.08-150	.2-80	3.95	(10-49)
		T1-6T NEW	1	.003-300	.003-300	.01-150	.02-50	5.95	(10-49)
		T2-1T	2	.07-200	.07-200	.1-100	.5-50	4.25	(10-49)
		T2.5-6T	2.5	.01-100	.01-100	.02-50	.05-20	4.25	(10-49)
		T3-1T	3	.05-250	.05-250	.1-200	.5-70	3.95	(10-49)
		T4-1	4	.2-350	.2-350	.35-300	2-100	2.95	(10-49)
		T4-6T	4	.02-250	.02-250	.05-150	0.1-100	3.95	(10-49)
		T5-1T	5	.3-300	.3-300	.6-200	.5-100	4.25	(10-49)
		T8-1T	8	.03-140	.03-140	.10-90	1-60	6.95	(10-49)
		T13-1T	13	.3-120	.3-120	.7-80	5-20	4.25	(10-49)
		T16-6T NEW	16	.03-75	.03-75	.06-30	.1-20	4.95	(10-49)
	TH	T4-1H	4	8-350	8-350	15-300	25-200	4.95	(10-49)
	TMO	TMO1-1T	1	.05-200	.05-200	.08-150	.2-80	6.45	(10-49)
		TMO2-1T	2	.07-200	.07-200	.1-100	.5-50	6.75	(10-49)
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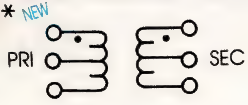
		† TMO3-1T	3	.05-250	.05-250	.1-200	.5-70	6.45	(10-49)
		TMO4-1	4	.2-350	.2-350	.35-300	2-100	4.95	(10-49)
		TMO5-1T	5	.3-300	.3-300	.6-200	5-100	6.75	(10-49)
		TMO13-1T	13	.3-120	.3-120	.7-80	5-20	6.75	(10-49)
B* NEW 	TT	TT1-6	1	.004-500	.004-500	.02-200	.1-50	5.95	(10-49)
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		TT2.5-6	2.5	.01-50	.01-50	.025-25	.05-10	5.25	(10-49)
		TT4-1	4	.05-200	.05-200	.02-50	1-30	4.95	(10-49)
		TT25-1	25	.02-30	.02-30	.05-20	.1-10	7.95	(10-49)
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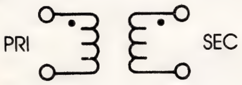
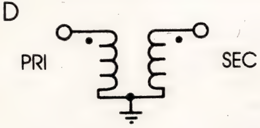
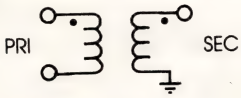
C 	T	T1-1	1	.15-400	.15-400	.35-200	2-50	2.95	(10-49)
		T1-6 NEW	1	.01-150	.01-150	.02-100	.05-50	4.95	(10-49)
		T1.5-1	1.5	.1-300	.1-300	.2-150	.5-80	3.95	(10-49)
		T1.5-6 NEW	1.5	.02-100	.02-100	.05-50	0.1-25	4.95	(10-49)
		T2.5-6	2.5	.01-100	.01-100	.02-50	.05-20	3.95	(10-49)
		T4-6	4	.02-200	.02-200	.05-150	.1-100	3.95	(10-49)
		T9-1	9	.15-200	.15-200	.3-150	2-40	3.45	(10-49)
		T16-1	16	.3-120	.3-120	.7-80	.5-20	3.95	(10-49)
		T36-1	36	.03-20	.03-20	.05-10	.1-5	5.95	(10-49)
	TH	T1-1H	1	8-300	8-300	10-200	25-100	4.95	(10-49)
		T9-1H	9	2-90	2-90	3-75	6-50	5.45	(10-49)
		T16-1H	16	7-85	7-85	10-65	15-40	5.95	(10-49)
	TMO	TMO1-1	1	.15-400	.15-400	.35-200	2-50	4.95	(10-49)
		TMO1.5-1	1.5	.1-300	.1-300	.2-150	.5-80	6.75	(10-49)
		† TMO2.5-6	2.5	.01-100	.01-100	.02-50	.05.20	6.45	(10-49)
		† TMO4-6	4	.02-200	.02-200	.05-150	.1-100	6.45	(10-49)
		TMO6-1	6	.3-200	.3-200	.5-150	5-50	6.45	(10-49)
		TMO9-1	9	.15-200	.15-200	.3-150	2-40	6.45	(10-49)
		TMO1.6-1	16	.3-120	.3-120	.7-80	5-20	6.45	(10-49)
D 	T	T2-1	2	.025-600	.025-600	.05-400	.5-200	3.45	(10-49)
		T3-1	3	.5-800	.5-800	.2-400	—	4.25	(10-49)
		T4-2	4	.2-600	.2-600	.5-500	.2-250	3.45	(10-49)
		T8-1	8	.15-250	.15-250	25-200	2-100	3.45	(10-49)
		T14-1	14	.2-150	.2-150	.5-100	2-50	4.25	(10-49)
	TMO	TMO2-1	2	.025-600	.025-600	.05-400	.5-200	5.95	(10-49)
		TMO3-1	3	.5-800	.5-800	2-400	—	6.95	(10-49)
		TMO4-2	4	.2-600	.2-600	.5-500	2-250	5.95	(10-49)
		TMO8-1	8	.15-250	.15-250	.25-200	2-100	5.95	(10-49)
		TMO14-1	14	.2-150	.2-150	.5-100	2-50	6.75	(10-49)
E 	FT	FT1.5-1	1.5	.1-400	.1-400	.5-200	1-100	29.95	(1-4)
	FTB	FTB1-1	1	.2-500	.2-500	.5-300	10-100	29.95	(1-4)
		FTB1-6	1	.01-125	.01-125	.05-50	.1-25	29.95	(1-4)
		■ FTB1-1-75	1	.5-500	.5-500	5-300	10-100	29.95	(1-4)

■ Denotes 75 ohm models

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0.1 dB over 1 dB frequency range
0.5 dB over entire frequency range

* Maximum Phase Unbalance
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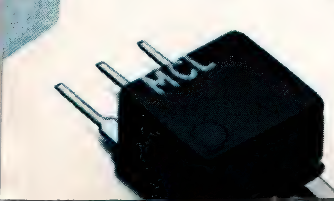

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CIRCLE NO 22

SIGNALS & NOISE

Military engineers lack social consciousness

Dear Editor:

EDN has chosen its own approach to defending its July 10 editorial (pg 47) and article (pg 293) on social consciousness. You were very circumspect in pointing out (in Signals & Noise, EDN, September 18, pg 32) that the editorial had not criticized the DoD nor had it characterized any engineer as a "hired hack."

Yet two practitioners of the electronics art saw fit to lash out because you expressed mild reservations about engineers who care nothing about the social implications of their work. It's unfortunate that they do not remember the story of the loyal German engineers of the 30s and 40s who dutifully put their skills at the service of their country —to generate V1 and V2 rockets, efficient gas ovens and crematoria for the victims of Nazism, and other boons to humanity.

I would go much further than EDN in asserting that there is indeed a lack of social consciousness in those engaged in military research and weapons systems development. Pointing out that DoD work is "rewarding" and is "always attempting to go beyond the state of the art, which greatly enhances personal satisfaction . . . " is adequate testimony that hired hacks do exist.

The Strategic Defense Initiative (SDI) is probably the best example of a technology gone berserk. Any good engineer knows that it is far preferable to *eliminate* a problem than it is to cobble up an expensive, complex, and inadequate solution (which is descriptive of SDI). Quite apart from any paranoia-based reluctance on the part of the USSR in past years is the fact that the USSR has nevertheless taken the initiative to cease nuclear weapons testing—*unilaterally*. Yet even this fails to move the technocrats here, who are immersed in "sweet, elegant solutions" to problems that are both avoidable and not worthy of human endeavor. As if to underscore his lack of comprehension of history, one of your critics asserted that the protesters of the 60s changed something from within. On the contrary, it was mass street protest, not conventional politics, that is credited with stopping the Vietnam War.

Sincerely yours,
David Wald
Santa Clara, CA

National defense is a moral issue

Dear Editor:

Regarding the article "As engineers' social consciousness matures, concerned groups act as the guiding light" (EDN, July 10, pg 293), I

Continued on pg 32

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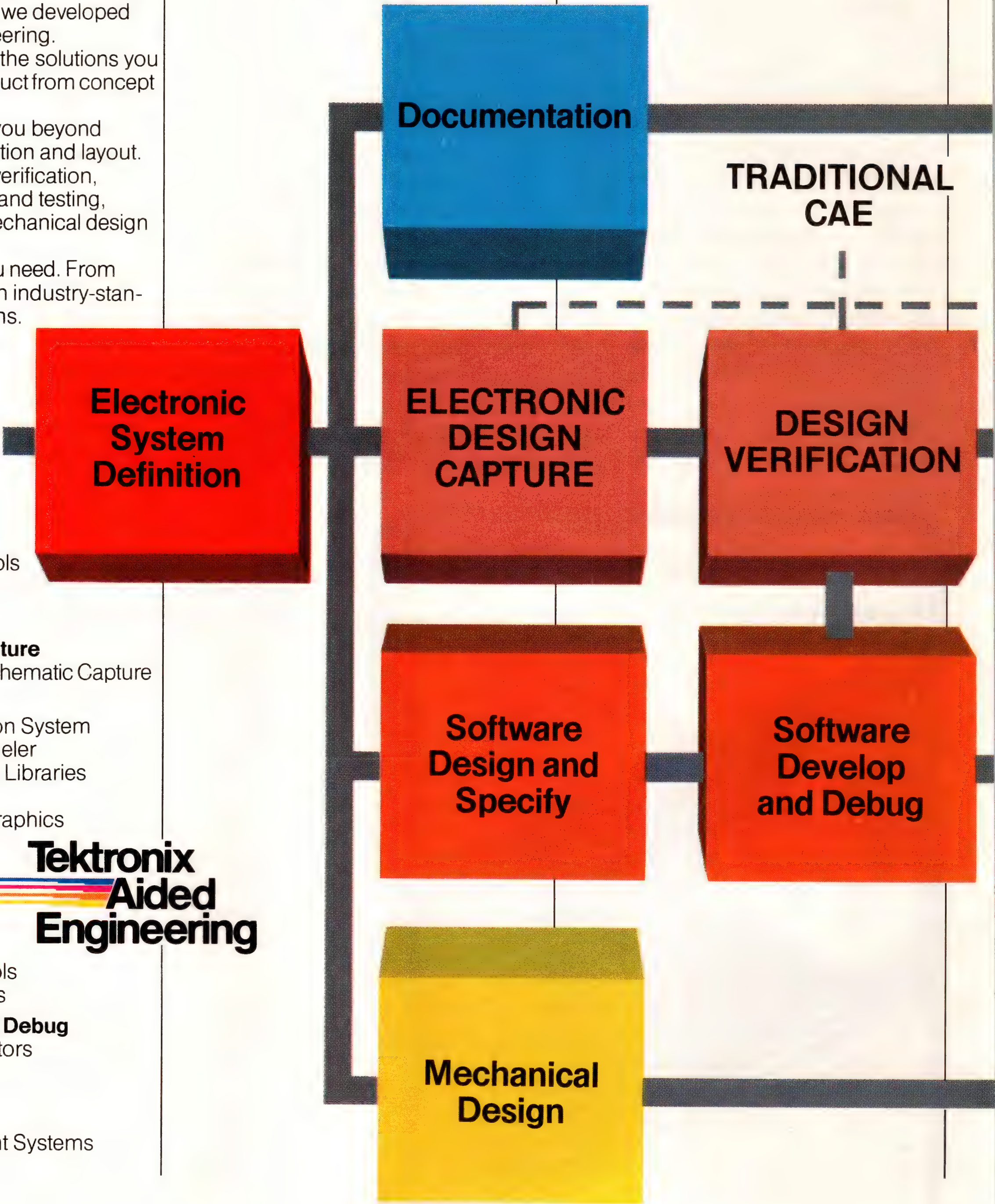
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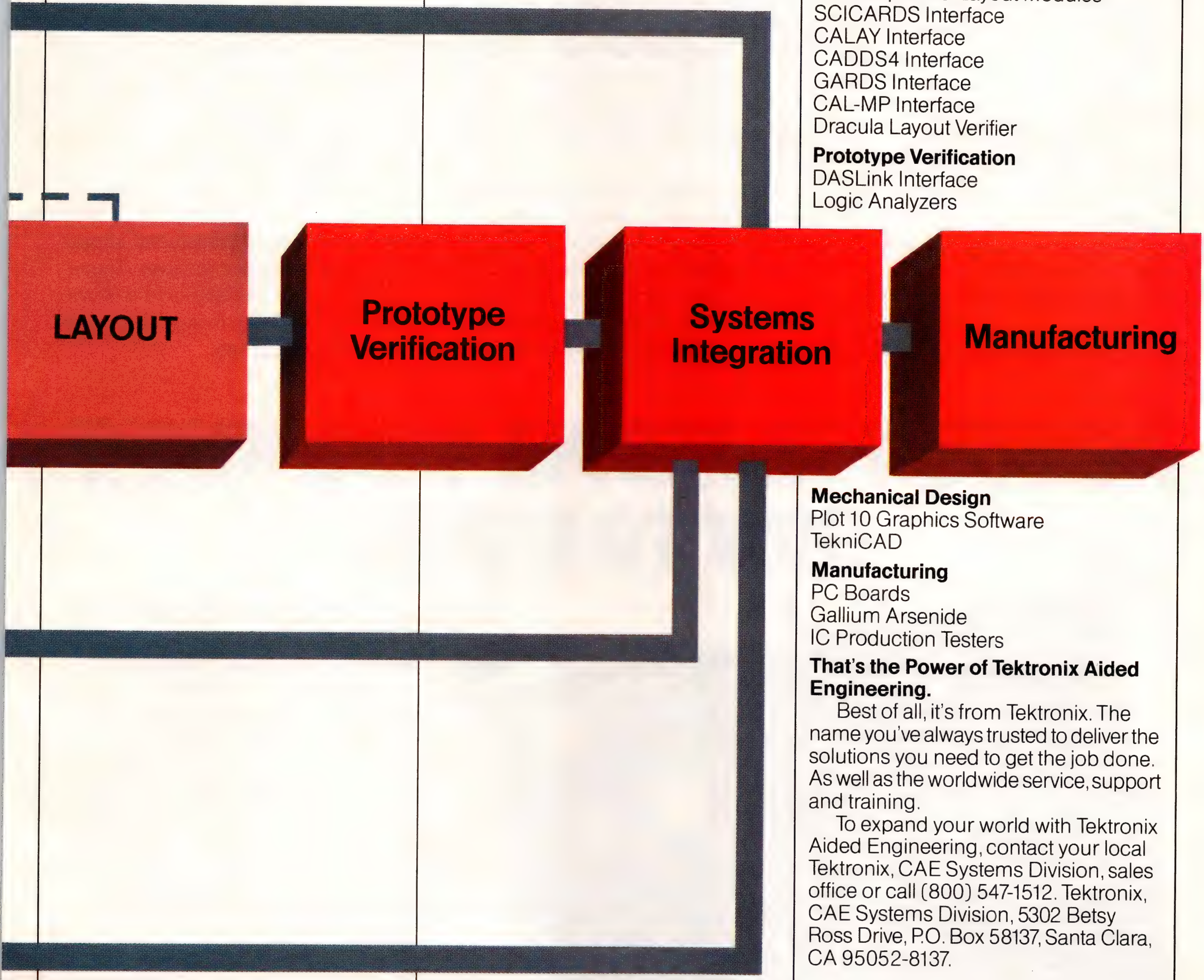

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CIRCLE NO 25

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must note that national defense and weapons development as moral issues do not exist in a vacuum. I, for one, have been involved in military R&D for forty years and have succeeded in making a number of contributions that have led to the publication of some eight books and many short items, most of which are unclassified.

We have local, state, and federal police who have various responsibilities to protect us as far as possible against hoods and criminals of all stripes. We can't disband these police, and we must support them technologically, or our lives would be in much greater danger than they are. (Heaven help us if we didn't have them.) As long as there is a single tyrannical regime in the world, we must remain strong.

As citizens of this nation—to which even many citizens from "curtain" countries (including so-called diplomats of the KGB and the GRU) will vote with their feet to come, even on temporary assignment—we must keep in mind that we have a responsibility to our neighbors, both within and without our borders, to further our mutual safety and to expose internal threats to it.

The Russians oppose SDI for only one reason. Even though it may not be perfect, SDI will make it much harder for them (as Khrushchev said) "to bury" us. This was Lenin's and Stalin's philosophy, but they believed they could get us to let down our guard so that we would bury ourselves. The real issue is, "At what point do our social responsibilities contribute to burying ourselves?"

I sympathize with the individuals whose idea is to vote their beliefs on these subjects, but I'm afraid they have allowed their priorities to endanger their neighbors and future generations. These issues can't be examined out of context of the some 66 million loyal Russians who have given their all, including their lives, suffering and dying in the Russian Gulag. (Cuba and almost all other curtain countries have similar records.)

Please help your readers to keep a balanced view of our world. Our military-industrial system has faults, as does our media system, but we must compare our system with others. Those voting with their feet in coming this way have already made this comparison. We have a legislative, judiciary, and executive triad that operates mostly openly (at times too open); they have their communist parties, their GRUs, and their KGBs, which operate in almost total secrecy. In our system, our media can publish things that cause great embarrassment almost without consequence; over there, you can suffer terribly or die in the Gulag or a brutal prison for much less serious offenses.

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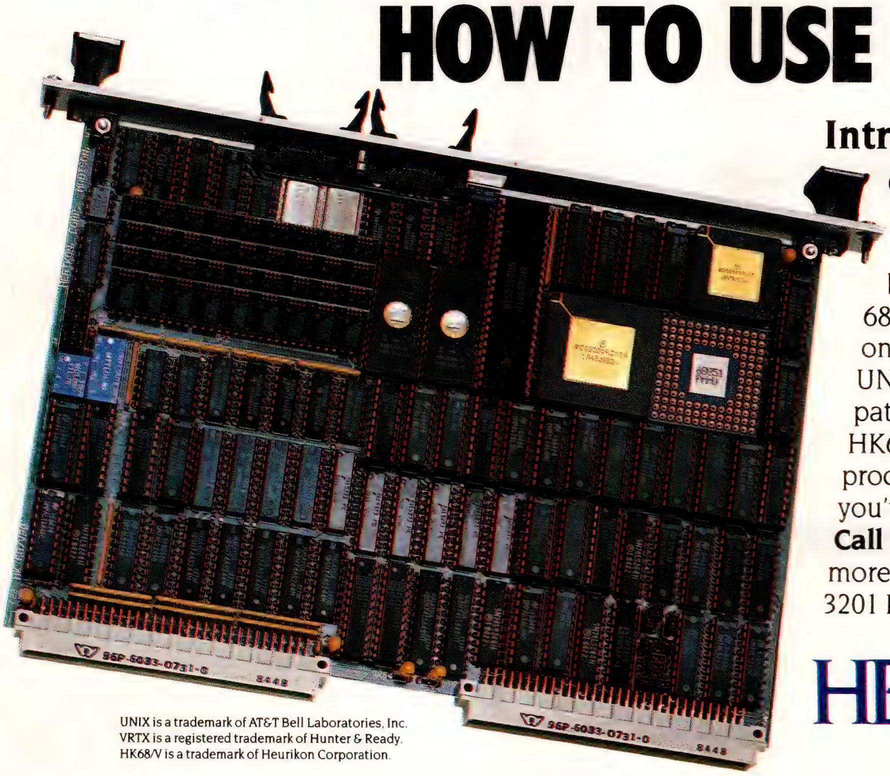

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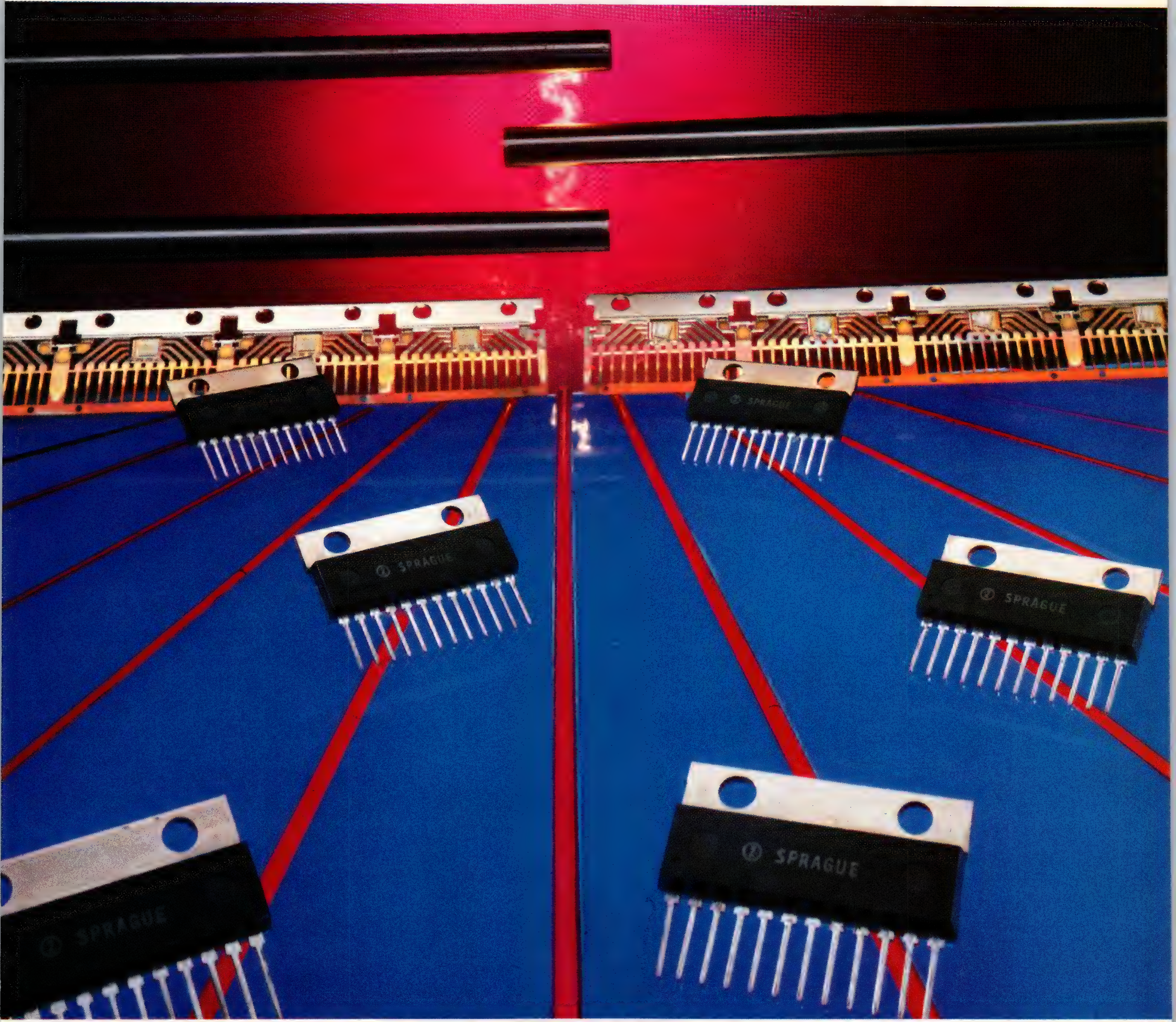

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CIRCLE NO 29

SIGNALS & NOISE

It is vital that we all keep our perspective on things!
Sincerely yours,
Keats A Pullen Jr
Kingsville, MD

Readers' comments

- *Social responsibility: EDN, July 10, pg 293*

"EDN or Staff Editor Deborah Asbrand should not endorse a political viewpoint ('As engineers' social consciousness matures, concerned groups act as the guiding light'). Both the title and the tone of this article imply endorsement. I would like to suggest devoting similar space for opposing points of view."
—PP, Santa Clara, CA

"The Professional Issues article was excellent. Not all EEs are conscienceless technomonsters. High technology and a nonconservative political viewpoint can coexist. Thank you!"*—JJ, Minneapolis, MN*

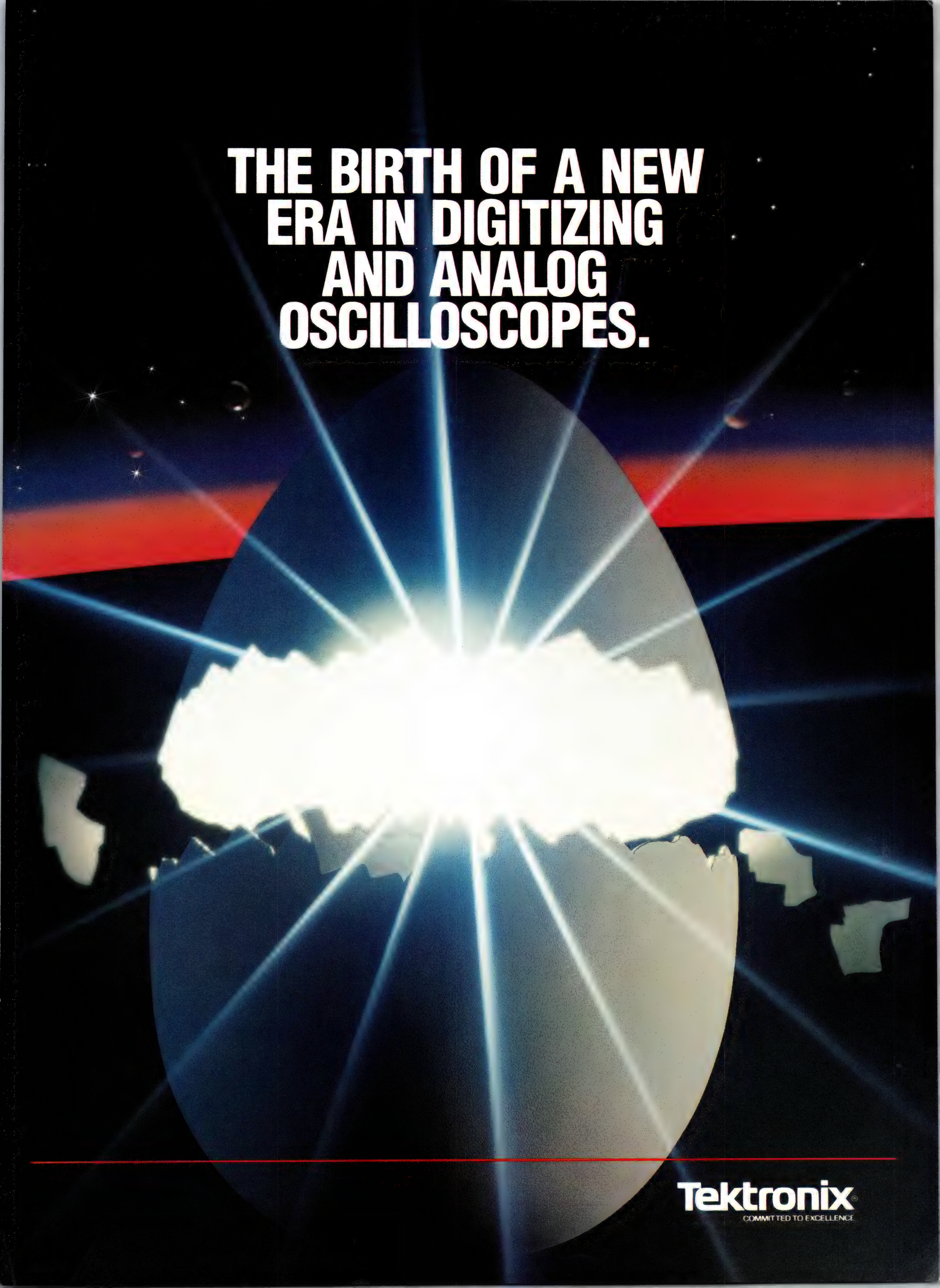
"Your Professional Issues section is *not* professional. Keep your interests within technological bounds."
—DF, Long Beach, CA

"Excellent Professional Issues article on social consciousness. This kind of article is all too rare."*—JS, Indian Head, MD*

"I particularly liked your Professional Issues column. Keep it up. It may be the *only* way that concerned engineers get to read up on these issues."*—AP, New York, NY*

WRITE IN

Send your letters to the Signals and Noise Editor, 275 Washington St, Newton, MA 02158. We welcome all comments, pro or con. All letters must be signed, but we will withhold your name upon request. We reserve the right to edit letters for space and clarity.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DIGITIZING	11401	11402	ANALOG	11301	11302
Bandwidth	500 MHz	1 GHz	Bandwidth	400 MHz	500 MHz
Risetime	700 ps	350 ps	Risetime	875 ps	700 ps
No. Channels[1]	1-12	1-12	No. Channels[1]	1-8	1-8
Vert. Sensitivity[4]	1 mV/div	1mV/div	Vert. Sensitivity[4]	1 mV/div	1 mV/div
Vert. Resolution	10-14 bits[3]	10-14 bits[3]			
Automatic Measurements	Min, Max, Mid, Mean, RMS, Peak-Peak, Rise, Fall, Width, Delay1, Cross, Period, Frequency, Main→Window Trigger, YT Area, YT Energy, Cursors		Automatic Measurements	Peak-Peak, Min, Max, Mid, Frequency, Period, Width, Duty Cycle	
Timebase Accuracy	100 ps + .002% of the measured interval		Built-in counter/timer	500 MHz 6 Function 10 digits	500 MHz 6 Function 10 digits

[1] Up to 8 traces may be displayed at once from any of up to 12 input channels.
[2] Absolute DC accuracy with full scale offset or Vc.
[3] 14-bit resolution obtained using signal averaging.
[4] Except with 11A71 which has 10mV/div

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How the new technology will simplify your life.

The 11000 Series, makes it unnecessary to learn oscilloscope theory. You get more out of your scope with less effort than ever before.

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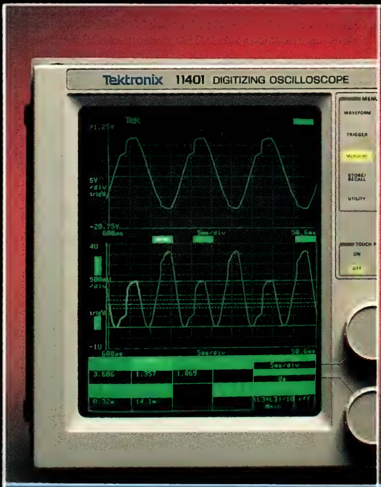
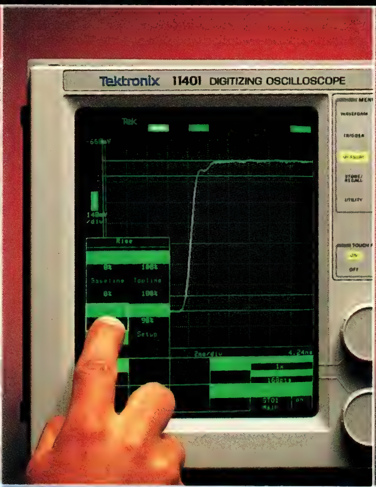
Or, push a button on the new probes to initiate an auto-range or a sequence of stored test setups—your hands and eyes never leave the job.

11401/11402 Digitizing Oscilloscopes

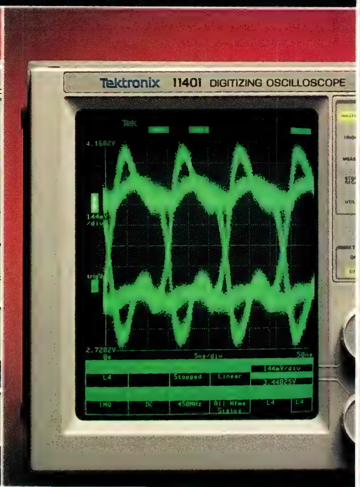
One example of innumerable waveform processing capabilities: square a voltage waveform and divide by a load resistance — (L3*L3)/10 — to make a power measurement.

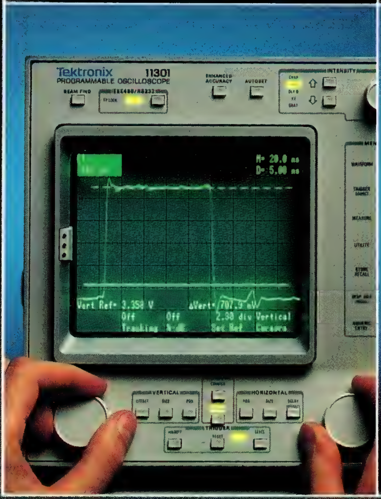


Customize automatic measurements to meet your needs. Touching any measurement result, for example, causes annotation to appear showing exactly where the measurement is being taken.



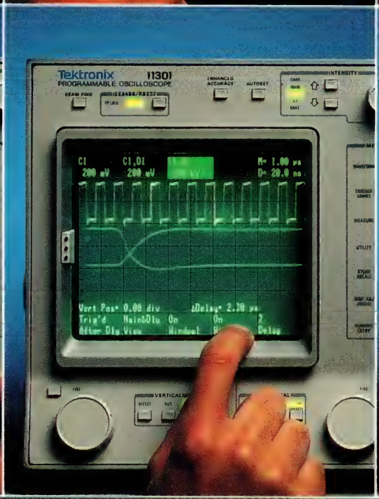
Point Accumulate Mode keeps all digitized points in display memory to help you handle complex displays such as eye diagrams, measure worst case jitter, or catch low rep-rate glitches.



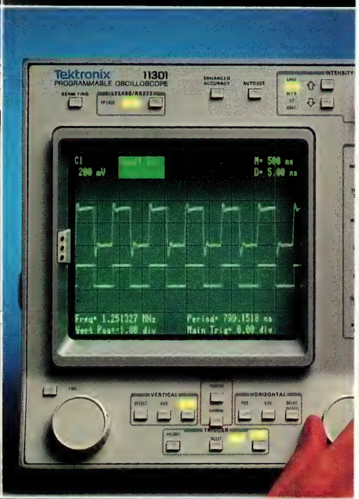


11301/11302 Analog Oscilloscopes

Call up cursors to help you make high-accuracy measurements, displayed in decibels, percent, degrees, volts or seconds.



Dual delayed sweeps allow expansion of the main sweep for close examination and accurate measurement of waveform parameters such as risetime and falltime.



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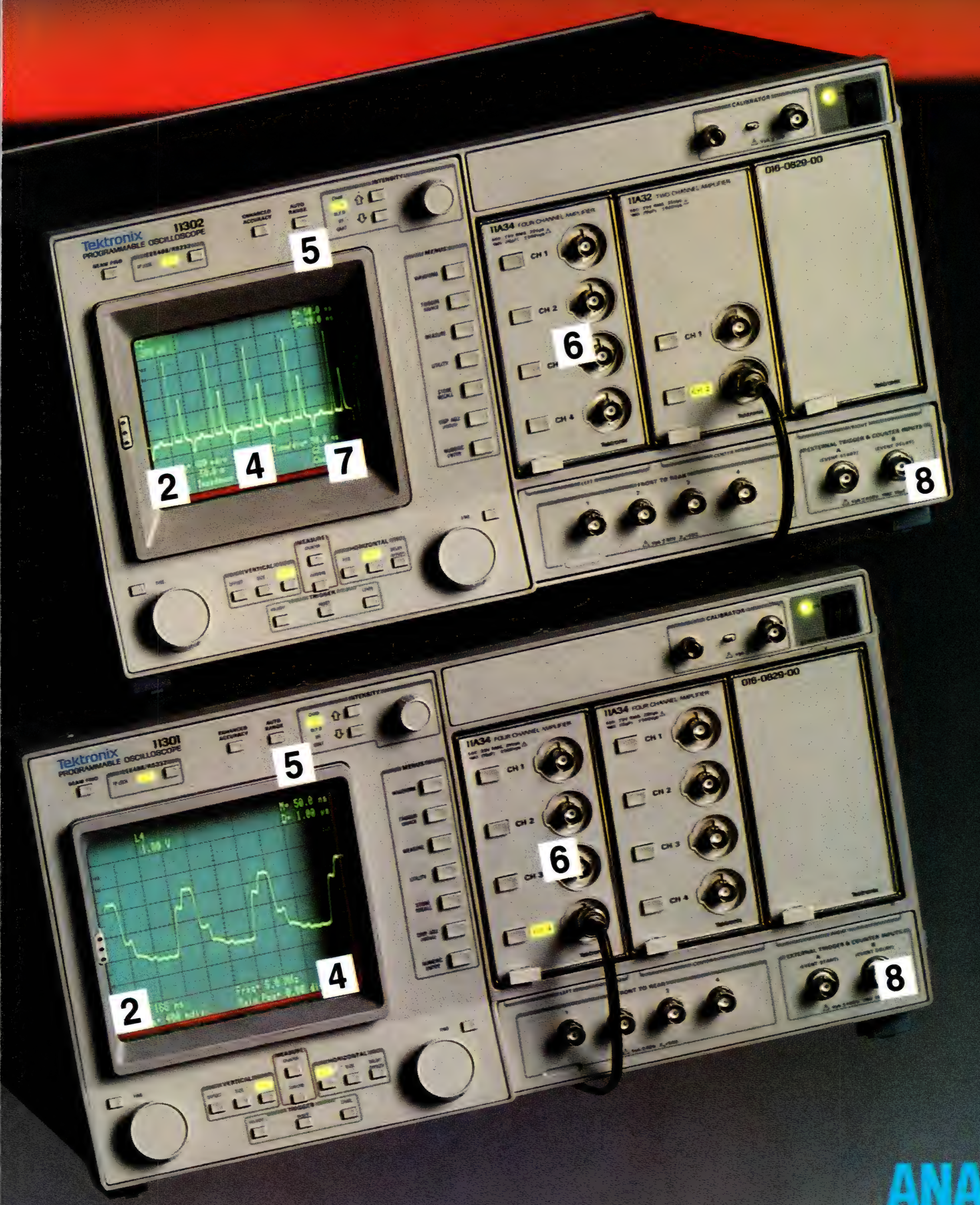
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PROGRAMMABLE OSCILLOSCOPE
11302
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2
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11A34 FOUR CHANNEL AMPLIFIER
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CALIBRATOR
Tektronix
PROGRAMMABLE OSCILLOSCOPE
11301
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6
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4
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11A34 FOUR CHANNEL AMPLIFIER
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5 AUTOSET FROM PROBE TIP. Push a button on the front panel or on the probe to set up a scaled and triggered waveform display, or to sequence automatically through a series of tests.

6 1 mV/DIV VERTICAL SENSITIVITY. Applies across the full bandwidth, right at the probe tip. Achievable on three new plug-ins.

7 MICROCHANNEL PLATE. Enables a single shot trace brightness in the 11302 almost 1000 times brighter than on conventional scopes—making even the fastest transients clearly visible to the eye.

8 500 MHz SIX FUNCTION COUNTER/TIMER. With 2 ns single shot resolution — 10 ps with averaging. Use with dual delayed sweeps for precise timing measurements between selected points. Counter/timer view trace ends guesswork.

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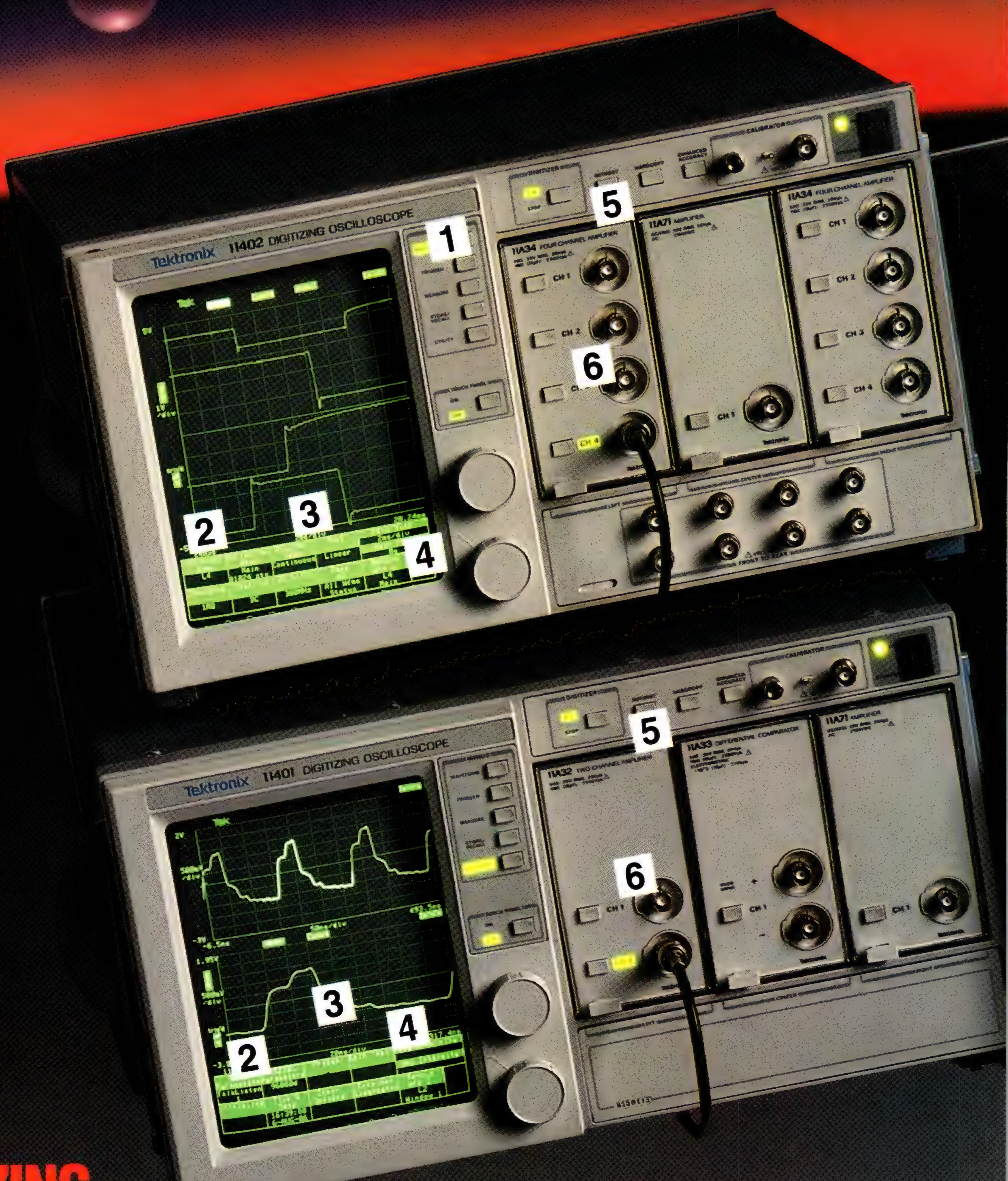
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11402 DIGITIZING OSCILLOSCOPE
1
5
11A34 FOUR CHANNEL AMPLIFIER
11A71 AMPLIFIER
11A34 FOUR CHANNEL AMPLIFIER
CH 1
CH 2
CH 3
CH 4
6
2
3
4
CALIBRATOR
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Tektronix
11401 DIGITIZING OSCILLOSCOPE
5
11A32 TWO CHANNEL AMPLIFIER
11A33 DIFFERENTIAL COMPARATOR
11A71 AMPLIFIER
6
3
4
2

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1 **1 GHz.** The 11402 Digitizing Oscilloscope features a full 1 GHz bandwidth right at the probe tip—with no sacrifice in vertical resolution—to help you make the most demanding voltage and timing measurements.

2 **UP TO 8 TRACES.** High-resolution screen lets you display up to eight waveforms simultaneously, with an update nearly as fast as an analog scope. No scopes ever let you see so much at once.

3 **10 ps HORIZONTAL RESOLUTION.** 10-bit vertical resolution is averageable to 14 bits. Self-calibration decreases error to less than 1% DC.

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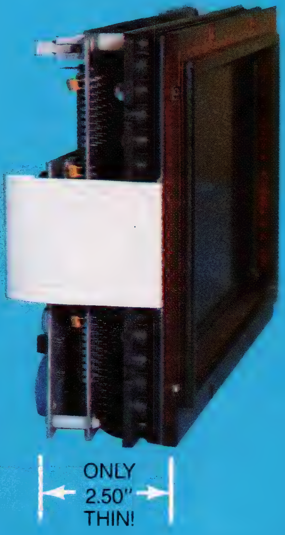

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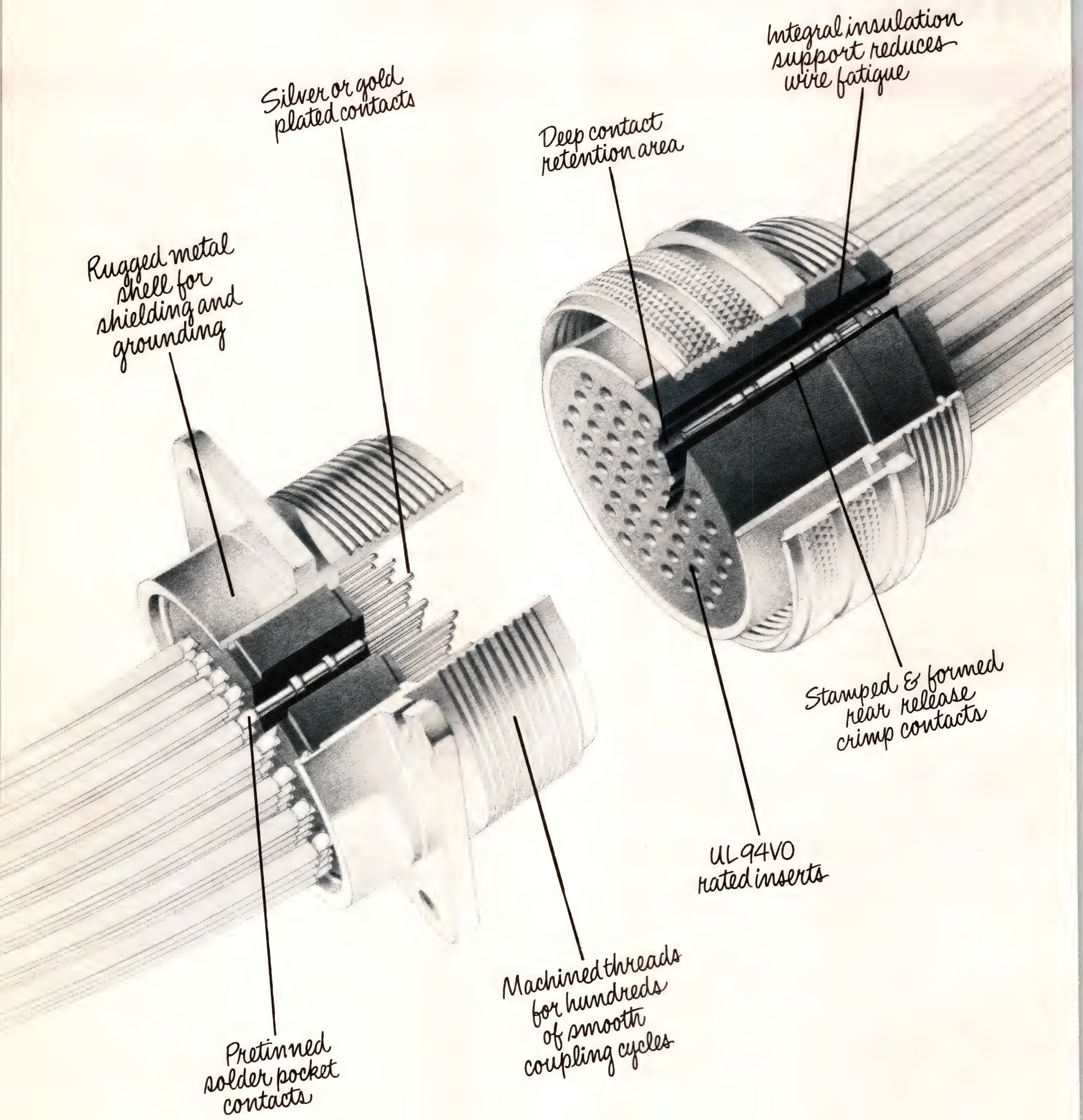
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CIRCLE NO 31

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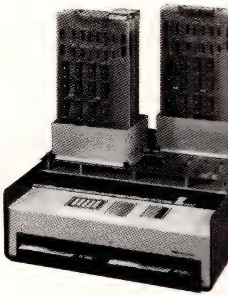

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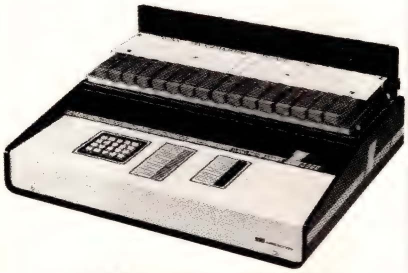

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CALENDAR

Buscon West (Bus/Board Users Show and Conference), Los Angeles, CA. Buscon, 17100 Norwalk Blvd, #116, Cerritos, CA 90701. (213) 402-1610. January 20 to 21.

Syscon (Subsystems Conference and Exposition), Los Angeles, CA. Syscon, 17100 Norwalk Blvd, #116, Cerritos, CA 90701. (213) 402-1610; (714) 552-4617. January 20 to 21.

Usenix Technical Conference, Washington, DC. Usenix Association, Box 385, Sunset Beach, CA 90742. (213) 592-3243. January 21 to 23.

Annual Reliability and Maintainability Symposium, Philadelphia, PA. J L Rodriguez, Allied Bendix Aerospace, 15825 Roxford St, Sylmar, CA 91342. (818) 367-0111, X2276. January 27 to 29.

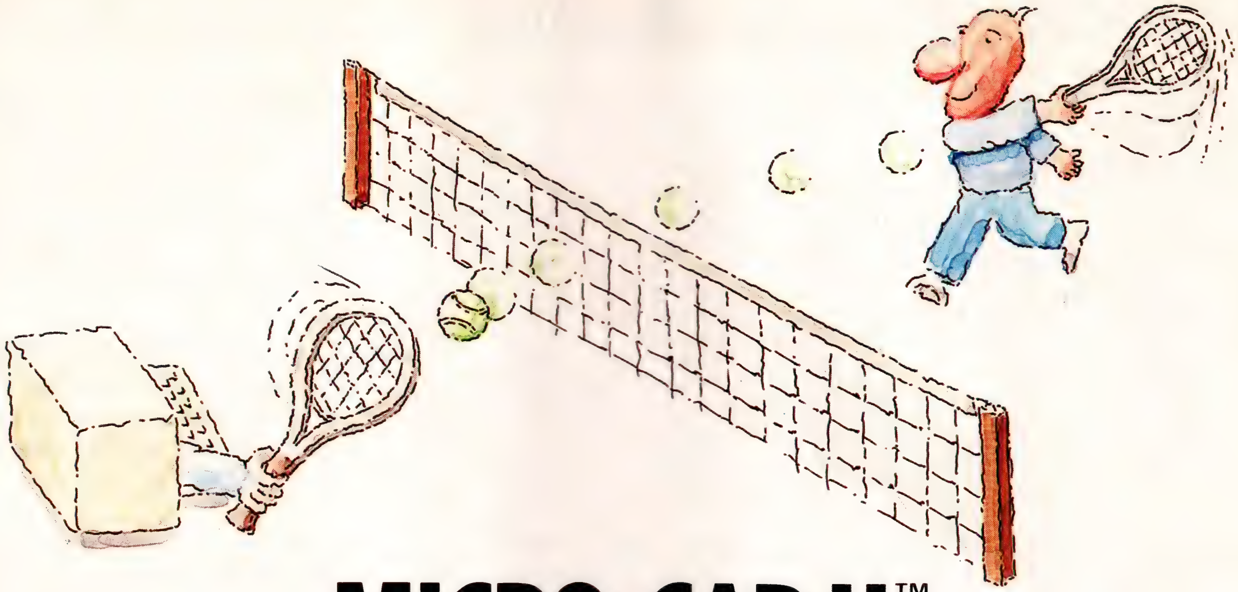
ASEE (Advanced Semiconductor Equipment Exposition and Technical Conference), Santa Clara, CA. Cartlidge & Associates, 1101 S Winchester Blvd, M259, San Jose, CA 95128. (408) 554-6644. January 27 to 29.

Computer Graphics New York '87, New York, NY. Exhibition Marketing and Management, 8300 Greensboro Dr, Suite 690, McLean, VA 22102. (703) 893-4545. January 28 to 30.

Invitational Computer Conference, Fort Lauderdale, FL. B J Johnson & Associates, 3151 Airway Ave, #C-2, Costa Mesa, CA 92626. (714) 957-0171. January 29.

Modern Electronic Packaging, Orlando, FL. Technology Seminars, Box 487, Lutherville, MD 21093. (301) 269-4102. February 9 to 11.

Invitational Computer Conference/Computer Graphics Series, San Jose, CA. B J Johnson & Associates, 3151 Airway Ave, #C-2, Costa Mesa, CA 92626. (714) 957-0171. February 10.



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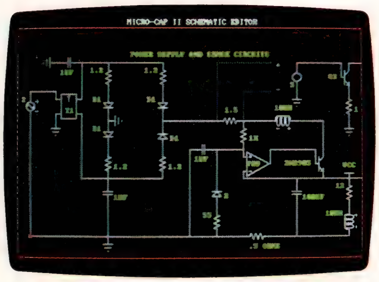
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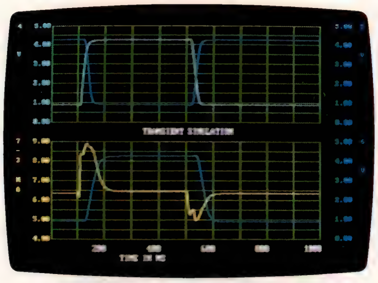

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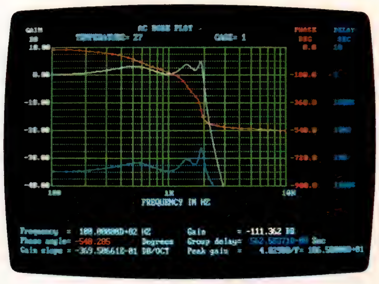

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154.52
188.58
1.3876
1.7566
187.43
18.347
17.961
16.975
1.8264
15.783
15.786
11.080
1.2136

18.905
153.47
185.98
175.16
19.090
129.34
101.09
18.236
17.647
16.154
1.8497
186.67
13.478
1.1654
118.75
1.1342
1.8514

1.7868
15.097
16.264
18.079
15.778
174.58
16.790
1.7805
152.78
1.5737
15.876
175.87
16.783
136.56
158.70
178.67
10.562

171.67
132.69
1.3789
158.77
197.35
19.875
1.9721
198.67
189.36
18.745
191.60
15.134
16.598
11.387
114.36
10.287
1.2905

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185.36
1.6243
17.265
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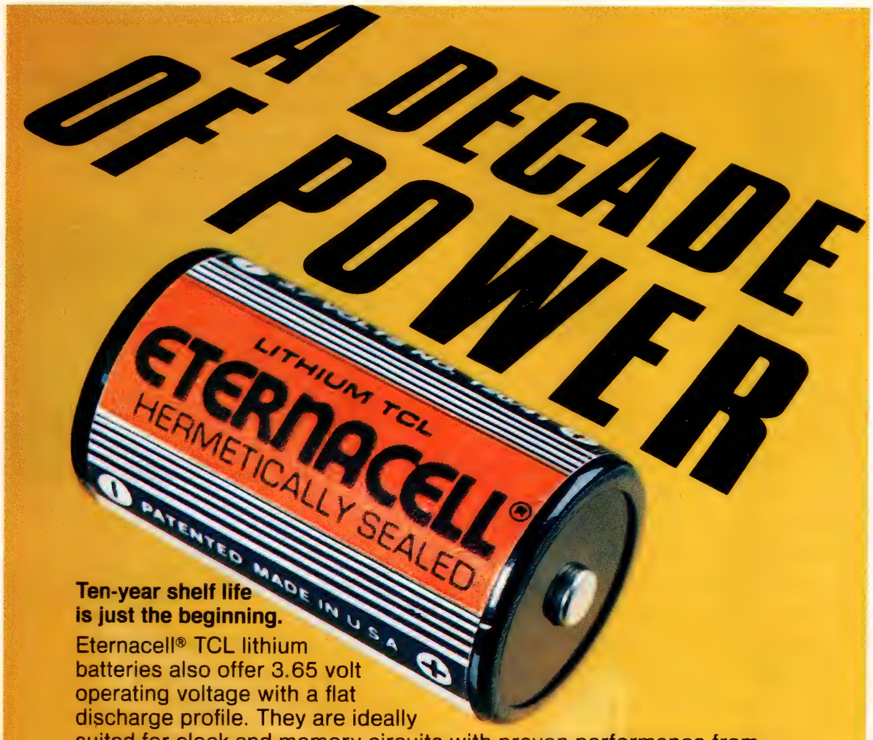

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Choose from more than twenty models to assure the right cell for your application. Call or write for our brochure. Power Conversion, Inc., 495 Boulevard, Elmwood Park, NJ 07407; (201) 796-4800, Telex: 13-0292.

Power Conversion, Inc.

CIRCLE NO 35

CALENDAR

Principles of Pulse Doppler Radar: High, Medium, and Low PRF (short course), Atlanta, GA. Georgia Institute of Technology, Department of Continuing Education, Atlanta, GA 30332. (404) 894-2547. February 10 to 12.

Invitational Computer Conference, Raleigh, NC. B J Johnson & Associates, 3151 Airway Ave, #C-2, Costa Mesa, CA 92626. (714) 957-0171. February 19.

Invitational Computer Conference/Computer Graphics Series, Dallas, TX. B J Johnson & Associates, 3151 Airway Ave, #C-2, Costa Mesa, CA 92626. (714) 957-0171. February 24.

Nepcon West, Anaheim, CA. CEG, Box 5060, Des Plaines, IL 60017. (312) 299-9311. February 24 to 26.

ISSCC (International Solid-State Circuits Conference), New York, NY. Lewis Winner, 301 Almeria Ave, Coral Gables, FL 33134. (305) 446-8193. February 25 to 27.

West Lightwave Expo, San Jose, CA. Lightwave, 235 Bear Hill Rd, Waltham, MA 02154. (617) 890-2700. February 25 to 27.

Spring National Design Engineering Show and Conference, Chicago, IL. CEG, 999 Summer St, Stamford, CT 06905. (203) 964-0000. March 2 to 5.

IEEE Applied Power Electronics Conference and Expo, San Diego, CA. Melissa Widerkehr, APEC '87, 655 15th St NW, Suite 300, Washington, DC 20005. (202) 347-5900. March 2 to 6.

Invitational Computer Conference, Austin, TX. B J Johnson & Associates, 3151 Airway Ave, #C-2, Costa Mesa, CA 92626. (714) 957-0171. March 3.

Introducing OptiLab™:

The Complete Microprocessor Development Toolbox.

You need the right tools to speed completion of your project and improve its quality.

That's why we created the OptiLab toolbox. The tools you want for beginning-to-end development and optimization of microprocessor code. OptiLab's fully-integrated, PC-based system lets you debug, analyze, modify, optimize, and test code in a seamlessly integrated environment. You can add your own cross-assembler, too.

The star of the OptiLab is Program Performance Analysis that helps you uncover invisible bugs, eliminate unneeded code, and cure program inefficiencies. OptiLab runs in real-time, is non-intrusive, and gives you outstanding performance at a remarkably low price.

There's more. OptiLab's 48-channel analyzer lets you track bus state activity and trap bugs fast. Monitor your software as it executes in real time with the full-featured 8/16-bit In-Circuit Emulator. Send test patterns with the Input Stimulus Generator and observe their effects. With the built-in EPROM Programmer, you can program devices without leaving OptiLab.

Orion offers you ready support for more than 150 different microprocessors. MicroTargets™ allow you to run and test your software even before you have working hardware. And our crack team of Applications Engineers is standing by if you need assistance.

But here's the real news. OptiLab is priced under $7,000. Or, you can start with a basic Orion system for as little as $2,995 and add capabilities as you need them.

Call now for complete information on OptiLab or other Orion microprocessor development tools. All Orion products are sold with a 15-day money-back guarantee.

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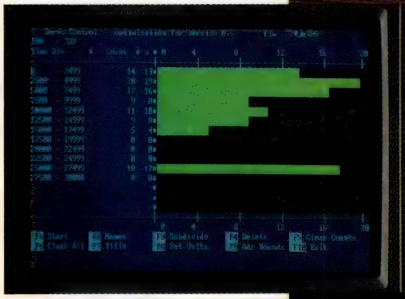
Analyzer **In-Circuit Emulator** **Line-by-Line Assembler** **Debug Package** **Performance Analyzer** **Stimulus Generator** **EPROM Programmer**		**ASSEMBLE** **DEBUG** **TEST** **OPTIMIZE**
		SHIP

Everything from assembly to final optimization of your software can be done with the OptiLab toolbox.

OptiLab presents a graphical display of actual program performance.



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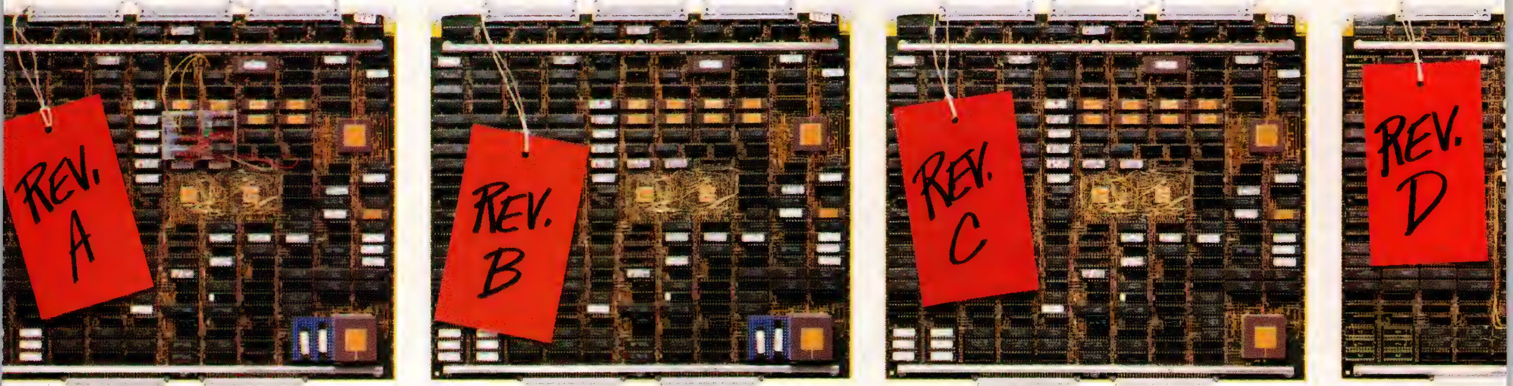
CIRCLE NO 36

ONE PROTOTYPE
THREE PROT
FIVE PROTOTYPE
SEVEN PROTO



Teradyne's new CAE tools help you get to market faster by

Designing VLSI circuit boards that work the first time isn't child's play. You can't do it without fast, accurate feedback on design and test quality.

Now count on Teradyne to help. With our new family of CAE products, you'll uncover flaws before they're cast in hardware. So you'll be able to jump from initial design directly to final prototype. And from design to manufacturing test.

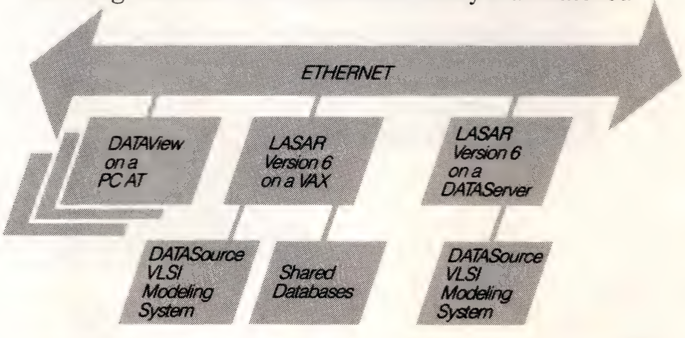
Start with a firm design foundation.

The process starts with DATAView our new design entry system. Running it on a standard AT-class PC, you can control the whole design process right at your desk. From schematic entry and waveform analysis on the PC to simulation and fault simulation on more powerful networked computers. All with the same mouse-and-menus, multiple-window interface.

You move from schematic capture to simulation effortlessly. DATAView's links with our LASAR Version 6 simulation system save hours of model compilation time. Incremental compiling lets you revise a design and resimulate in minutes.

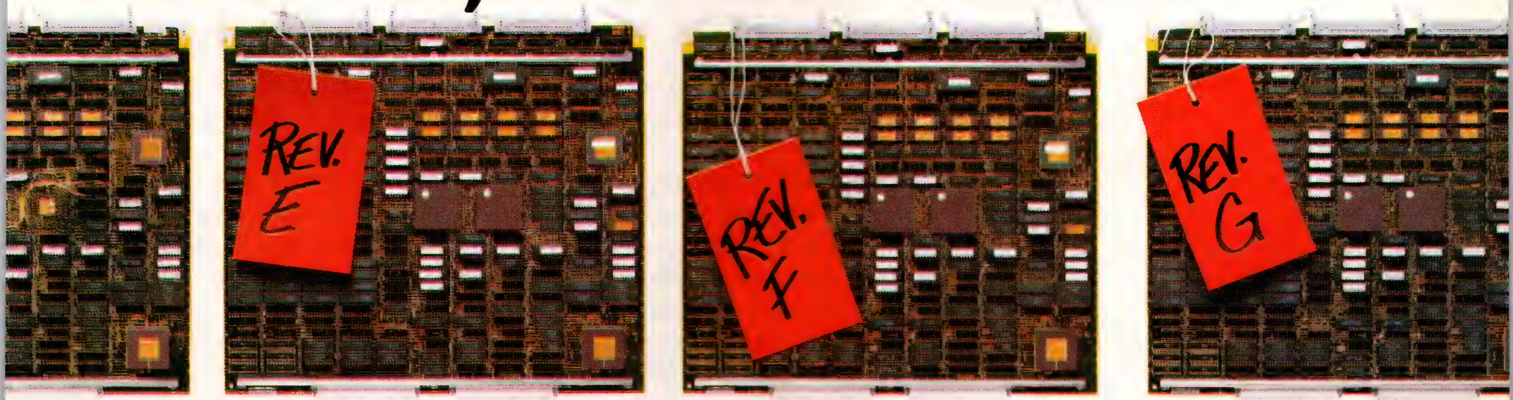
Make your design work together before it comes together.

LASAR Version 6 is the only sure way to avoid multiple trips to artwork as well as costly rework steps in manufacturing. Because its simulation accuracy is unmatched


ETHERNET
DATAView on a PC AT
LASAR Version 6 on a VAX
LASAR Version 6 on a DATAServer
DATASource VLSI Modeling System
Shared Databases
DATASource VLSI Modeling System

Teradyne networks advanced CAE tools for convenience *and* performance.

WO PROTOTYPE,
OTYPE FOUR.
, SIX PROTOTYPE,
TYPE, MORE.



giving you a working prototype the first time.

for analyzing PC board designs prior to prototyping. For instance, LASAR takes full device timing specifications into account for true worst-case timing analysis. And it eliminates shared timing ambiguity in reconverging signals. Both of which mean LASAR finds real design errors reliably.

Finally, you can use LASAR fault simulation. It will uncover testability problems and untested circuit functions before it's too late.

Simulation without trial and tribulation.

LASAR also takes care of the board modeling problem. It includes models of over 4000 devices. And the most popular gate array libraries.

For new VLSI parts, our DATASource hardware modeling system uses actual devices instead of software models. A single system supports multiple users and concurrent fault simulation. With extraordinarily fast response.

LASAR and DATASource work with any VAX. For simulations up to 25 times faster, you can use our new parallel/multiprocessing host, DATAServer. It will give you quick results, with full LASAR precision.

Teradyne makes it easy.

If you want to avoid multiple prototypes and get to market faster with better products, Teradyne's new CAE system is the way. Why not call Daryl Layzer at (617) 482-2700, ext. 2808 for more information. Or write Teradyne, 321 Harrison Avenue, Boston, MA 02118.

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TERADYNE

We measure quality.

CIRCLE NO 37

EDITORIAL

Let's get NASA back on track

A year after the Challenger disaster, NASA still seems paralyzed and mired in indecision. It's time to decide whether we want to expand our space program or to abandon space exploration to the Russians, Japanese, and Europeans. If we choose to continue our space program, we need a renewed sense of pride, as well as activities that provide measurable success. Also, one technology must never again so completely dominate all others. For example, by declaring the space shuttle our primary launch system for space exploration, we stifled technology that might now be available to launch unmanned probes into space. One accident effectively blocked new attempts to explore space and to put strategically important satellites into orbit. Astronomical and planetary missions such as Galileo, Magellan, and Ulysses are years behind schedule.

Because of our lack of alternative launch capabilities, our efforts in exploring space have lost a lot of momentum, and other nations are quick to fill the vacuum. The European Ariane program will launch some of the waiting payloads (although that program also suffers from reliance on a single technology). Chinese and Japanese space programs may also provide commercial launch services in the near future. With the loss of the Challenger, available payload slots are at a premium, and many US payloads will remain unlaunchable at any price.

Retired scientist-astronaut Owen K Garriot recently proposed a heavy-launch rocket that could be built with private funds. Hughes Aircraft Co and Boeing Aerospace Co seem to agree. Both companies want to develop jointly a 3-stage, medium-launch vehicle that incorporates the best features of an older Saturn-like rocket, along with structures and electronic systems developed for the shuttle. Basing the vehicle on available technology answers our immediate need to get back into space. However, we must also invest in new technologies that hold promise for the future.

Before we can get NASA back into the space-exploration business, we also need a strong leader, with sound technological vision, who can set our course. None of today's administrators seem able to capture and focus our imagination the way Werner Von Braun and John Kennedy did in the early 60s. Neil Armstrong and Frank Borman, where are you?

Jon Titus

Jon Titus
Editor

After 16 years in the military market, we've learned it's no picnic.

It's war.

So Intersil is armed to the teeth.

When your objective is the military IC market, you'd better be prepared for a fight.

That's why Intersil, under the leadership of General Electric, has invested over $50 million to field one of the best equipped, most highly motivated military forces in semiconductors today.

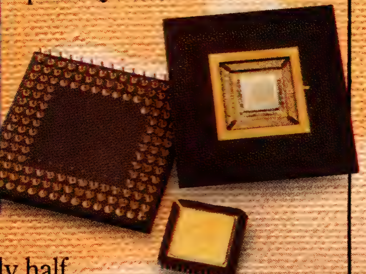
Over 300 military-compliant parts. And counting.

As proof of Intersil's military preparedness, we offer our arsenal of JAN QPL and 883B, Rev. C-compliant parts.

The last time we counted off, we had over 300. Including analog switches, JFETs, multiplexers, voltage converters, op amps, power supply management ICs, UARTs, microcontrollers, timers and A/D and D/A converters.

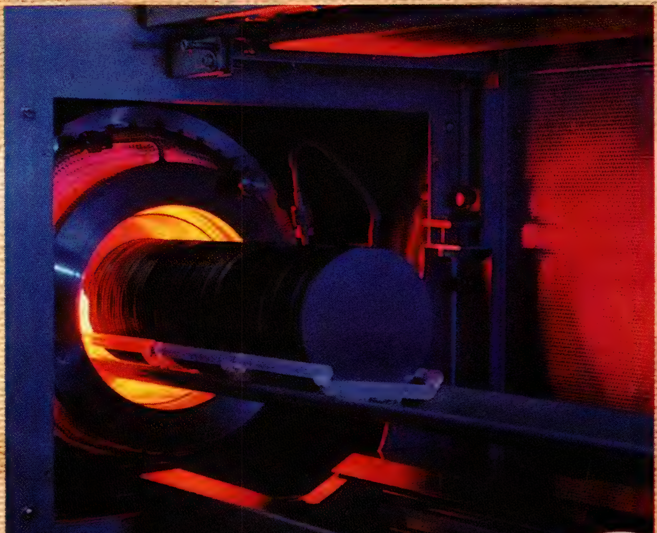
We started stockpiling QPLs in 1974, with our 2N5114 JFET.

Today we're adding to our list—and recording firsts—faster than ever in our military history. For example, our AD7541 recently became the first 12-bit D/A converter to pass QPL muster.



But as you know, a long list of QPL parts is only half the battle. You've also got to be able to deliver them on time, in volume.

Once again, Intersil's got you covered.



If you need the security of a bonded inventory, you've got it. Do you want off-the-shelf inventory at any of our military distributors? No problem.

We can document our military commitment with 10,000 Source Control Drawings.

Of course, part numbers can never take the place of commitment. And you can be sure Intersil has no intention of being out-gunned in that area, either.

As proof, we offer our *active* file of 10,000 Source Control Drawings.

Some suppliers have apparently turned their backs on the idea of working from a customer's own drawings.

Not Intersil. We continue to work from SCDs, as we have from day one.

If you prefer to work from Military (formerly called DESC) drawings, we have 59 on hand, with more to follow.

Anything's possible with Great Engineering.

We'll also offer you a wide choice of military-compliant processing options, including MIL-M-38510, MIL-S-19500, tested to MIL-STD-883B, Rev. C and MIL-STD-750. Or you can specify additional QC options, equivalent to Class "S" processing, at considerable savings.

Four fabs certified by DESC.

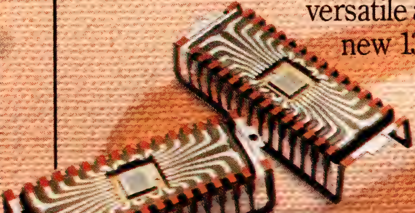
Armies travel on their stomachs; IC suppliers on their fabs.

That's why Intersil has built four fabrication facilities, all DESC-certified for JAN38510 CMOS and bipolar production. That will keep our shelves well-stocked.

And to make sure they're always stocked with technologically superior parts, we're also designing the VLSI weapons of the future.

We're turning out a new generation of more versatile analog switches with our new 130-volt CMOS process.

We're designing highly advanced, very low noise analog devices with our new BiMOS process.



And we've mobilized our 1.5-micron AVLSI capability to produce high performance signal processing and data conversion systems in volume.

We've also armed ourselves with the latest automated high-rel assembly systems and automatic test equipment. And we've equipped an incredible Failure Analysis Lab with all the tools of modern QA warfare. Including scanning electron microscopy, voltage contrast and back-scatter electron imaging systems.

As you can see, Intersil is coming after the military market. And we're taking no prisoners.

So if you need more information on any Intersil high-reliability or military-compliant product, call

1-800-4GE-SEMI, ext. 901.

(In NY State, 1-800-2GE-SEMI, ext. 901.)

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For free on-line information dial 1-800-345-7335 (203-852-9201 in Connecticut) and follow the On-Line Instructions printed on the back.

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When you see what Intersil has for the military, you'll be glad we're on your side.

Intersil QPL/Hi-Rel Devices

Data Acquisition Products

JM38510

12702BEA	AD7520UD
12703BVA	AD7521UD
12704BVC	AD7541TD

Analog Switch Products

JM38510

10501BEA	IH5040MDE
10501BEC	IH5040MDE
10502BEA	IH5041MDE
10502BEC	IH5041MDE
10503BEA	IH5042MDE
10503BEC	IH5042MDE
10504BEA	IH5043MDE
10504BEC	IH5043MDE
11101BAC	DG181AL
11101BCC	DG181AP
11101BIC	DG181AA
11101BCA	DG181AP
11102BAC	DG182AL
11102BCC	DG182AP
11102BIC	DG182AA
11102BCA	DG182AP
11103BAC	DG184AL
11103BEC	DG184AP
11103BEA	DG184AP
11104BAC	DG185AL
11104BEC	DG185AP
11104BEA	DG185AP
11105BAC	DG187AL
11105BCC	DG187AP
11105BIC	DG187AA
11105BCA	DG187AP
11106BAC	DG188AL
11106BCC	DG188AP
11106BIC	DG188AA
11106BCA	DG188AP
11107BAC	DG190AL
11107BEC	DG190AP
11107BEA	DG190AP
11108BAC	DG191AL
11108BEC	DG191AP
11108BEA	DG191AP
12302BEA	DG201AP
12302BEC	DG201AP

New JM38510 QPL's Forthcoming

Analog Switch

10505BEC	IH5044
10505BEA	IH5044
10506BEA	IH5045
10506BEC	IH5045
11101BIA	DG181
11102BIA	DG182
11105BIA	DG184
11106BIA	DG185
11601BCC	DG300A
11601BCA	DG300A
11602BCC	DG301A
11602BCA	DG301A
11603BCA	DG302A
11603BCC	DG302A
11604BCA	DG303A
11604BCC	DG303A
19001BXC	IH6116
19003BXC	IH6216
19007BEA	IH6108
19007BEC	IH6108
19008BEA	IH6208
19008BEC	IH6208

Military DWG. No.

DESC77052-01EA	IH6108MJE
DESC77052-01EC	IH6108MDE
DESC77052-01EA	IH6108MDE
DESC77053-01EA	DG201AK
DESC77053-01EC	DG201AP
DESC77053-01EA	DG201AP
DESC78014-01CA	DG129AK
DESC78014-01CC	DG129AP
DESC78014-01CA	DG129AP
DESC81006-01AC	IH5040MFD
DESC81006-01EC	IH5040MDE
DESC81006-01EA	IH5040MDE
DESC81006-02AC	IH5041MFD
DESC81006-02EC	IH5041MDE
DESC81006-02EA	IH5041MDE
DESC81006-02IA	IH5041MTW
DESC81006-02IC	IH5041MTW
DESC81006-02IB	IH5041MTW
DESC81006-03AC	IH5042MFD
DESC81006-03EC	IH5042MDE
DESC81006-03EA	IH5042MDE
DESC81006-03IA	IH5042MTW
DESC81006-03IC	IH5042MTW
DESC81006-03IB	IH5042MTW
DESC81006-04AC	IH5043MFD
DESC81006-04EA	IH5043MJE
DESC81006-04EC	IH5043MDE
DESC81006-04EA	IH5043MDE
DESC81006-05AC	IH5044MFD
DESC81006-05EA	IH5044MJE
DESC81006-05EC	IH5044MDE
DESC81006-05EA	IH5044MDE
DESC81006-05IA	IH5044MTW
DESC81006-05IC	IH5044MTW
DESC81006-05IB	IH5044MTW
DESC81006-06AC	IH5045MFD
DESC81006-06EA	IH5045MJE
DESC81006-06EC	IH5045MDE
DESC81006-06EA	IH5045MDE
DESC81006-06IA	IH5045MTW
DESC81006-06IC	IH5045MTW
DESC81006-06IB	IH5045MTW
DESC81006-07AC	IH5046MFD
DESC81006-07EA	IH5046MJE
DESC81006-07EC	IH5046MDE
DESC81006-07EA	IH5046MDE
DESC81006-08AC	IH5047MFD
DESC81006-08EA	IH5047MJE
DESC81006-08EC	IH5047MDE
DESC81006-08EA	IH5047MDE
596285131-04XA	IH5116MJI
596285131-04XA	IH5116MDI
596285131-04XC	IH5116MDI
596285131-05XA	IH5216MJI
596285131-05XA	IH5216MDI
596285131-05XC	IH5216MDI
596285131-06EA	IH5208MJE
596285131-06EA	IH5208MDE
596285131-06EC	IH5208MDE

MIL-S-19500 Transistors

2N3821JAN
2N3821JTX
2N3821JTXV
2N3823JAN
2N3823JTX
2N3823JTXV

2N4091JAN
2N4091JTX
2N4091JTXV
2N4092JAN
2N4092JTX
2N4092JTXV
2N4093JAN
2N4093JTX
2N4093JTXV

2N4856JAN
2N4856JTX
2N4856JTXV
2N4857JAN
2N4857JTX
2N4857JTXV

2N4858JAN
2N4858JTX
2N4858JTXV
2N4859JAN
2N4859JTX
2N4859JTXV

2N4860JAN
2N4860JTX
2N4860JTXV
2N4861JAN
2N4861JTX
2N4861JTXV
2N5114JAN
2N5114JTX
2N5114JTXV

2N5115JAN
2N5115JTX
2N5115JTXV
2N5116JAN
2N5116JTX
2N5116JTXV

Latest List of MIL-STD-883B Rev. C Compliant Devices

Data Acquisition Products

883B Rev C.

AD7520SD/883B
AD7320TD/883B
AD7520UD/883B
AD7521SD/883B
AD7521TD/883B
AD7533SD/883B
AD7533TD/883B
AD7533UD/883B
AD7541SD/883B
AD7541TD/883B
ICL7134UJMJ1/883B
ICL7134UKMJI/883B
ICL7134ULMJI/883B
ICL7662MTV/883B
ICL8038AMJD/883B
ICL8038BMJD/883B
ICL8069DMSQ/883B
ICL8212MTY/883B

Timer/Counter Circuits

883B Rev C.

ICM7555MTV/883B
ICM7556MJD/883B

Amplifiers-Operational

883B Rev C.

ICL8023MJE/883B

Analog Switch Products

883B Rev C.

D123AK/883B
D123AL/883B
D125AK/883B
D125AL/883B
D129AK/883B
D129AL/883B
DG126AK/883B
DG126AL/883B
DG129AK/883B
DG129AL/883B
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IH5150MJE/883B
IH5150MTW/883B
IH5151MFD/883B
IH5151MJE/883B
IH5208MJE/883B
IH5216MJI/883B
IH5341MTW/883B
IH5352MJE/883B
IH6108MJE/883B
IH6116MJI/883B
IH6201MJE/883B
IH6208MJE/883B
IH6216MJI/883B

Microcontrollers, Microperipherals, Memory

883B Rev C.

IM6402-1MJL/883B
IM6402AIJL/883B
IM6402AMJL/883B
IM6402IJL/883B
IM6653AMJG/883B
IM6653MJG/883B
IM6654-1IJG/883B
IM6654AMJG/883B
IM6654MJG/883B

New 883B Rev C. Devices Forthcoming

ICL8013
ICL8021
ICL7667
ICL7115
ICL7109
ICM7170

On-Line Instructions

Dial 1-800-345-7335 (in CT 203-852-9201). On any ASCII terminal or PC with a 300 or 1200-baud modem (EVEN or IGNORE parity, 7 data bits, 1 stop bit). At "Enter Response Code," type GEIHIREL.

INTERSIL

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CIRCLE NO 38

Reader Vote CONTEST

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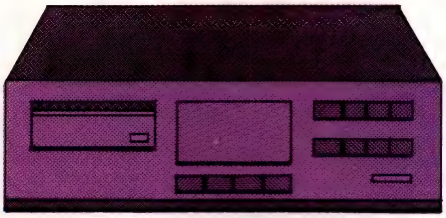

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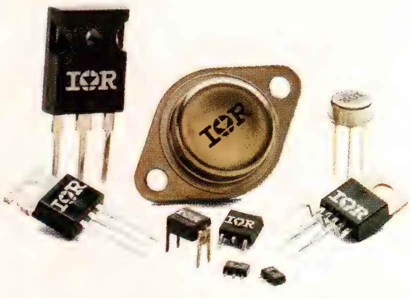

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CIRCLE NO 39

Design steps improve effective resolution of digitizing scopes, waveform digitizers

Chris Everett, *Regional Editor*

Sampling rates in digitizing oscilloscopes and waveform digitizers are now at the 1G-sample/sec level and climbing, and you can now select a digitizing instrument with a bandwidth as high as 1 GHz. Wider bandwidths and faster input signals, however, result in the introduction of more noise to the digitizing process. More noise leads to reduced vertical resolution, which in turn contributes to lower measurement accuracy, but high-performance oscilloscopes and waveform recorders are incorporating low-noise designs and other techniques, such as averaging and lowpass filtering, to increase their vertical resolution.

***Both time- and frequency-domain displays are available** in Sequence's Model 3000 waveform digitizer. The 1G-sample/sec, 10-bit digitizer uses a design incorporating a parallel-processing array to limit unwanted noise and increase the effective bit resolution.*

To better understand the noise problems scope and digitizer makers face, you should review some basic concepts. An ideal A/D converter generates $Q/\sqrt{12}$ rms quantizing noise in an $f_S/2$ bandwidth when digitizing a spectrally pure sine wave. (Q represents the weight of the least significant bit of the converter, and f_S is the sampling frequency.) The ratio of the signal (a full-scale sine wave) over the quantizing noise generated by an ideal N-bit A/D converter is $6.02N+1.8$ dB. For an ideal 16-bit converter, the S/N ratio is 98.12 dB. The resolving power of the 16-bit converter—that is, the smallest signal the converter can detect—is 96.3 dB (**Table 1**). Consequently, the quantizing noise in an ideal converter does not affect its resolution.

Ideally, the converter's quantizing noise level is independent of the input signal's amplitude and frequency as long as the signal's amplitude falls within the A/D converter's operating range. Practically, though, the A/D converter's noise floor increases with increasing signal frequency and with increasing signal amplitude. Also, the analog and digital circuitry in front of an A/D converter can add noise to the input signal and further reduce the actual effective resolution of the analog-to-digital conversion process.

Noise reduces resolution

One way manufacturers determine the effective resolution of a digitizing oscilloscope or waveform recorder is to measure the S/N ratio of the instrument and convert the answer from decibels to the number of bits. You will see this spec expressed as "effective bits" or "effective bit resolution."

For example, the Sequence Model 3000, a 1G-sample/sec waveform digitizer, has a 10-bit A/D converter. If you digitize a 350-MHz sine wave, you'll find that the resulting measurement has an effective resolution of eight bits. For lower-frequency signals, the effective resolution improves—for example, 8.8 bits for a 100-MHz signal.

Model 3000's analog input bandwidth is 350 MHz. Its input circuitry includes a programmable input attenuator (with 50-mV/div to 1V/div sensitivity) and offset control. You control the digitizer from an IBM PC/XT or PC/AT. In fact, you can control eight 3000s from a PC/XT.

To reduce generated noise within the digitizer—and thereby increase the effective resolution—Model 3000 uses a proprietary A/D-converter design, which does not include CCDs or monolithic flash converters. The parallel-processing-array design uses hybrid technology and yields a time-aperture-jitter spec of less than 3 psec rms.

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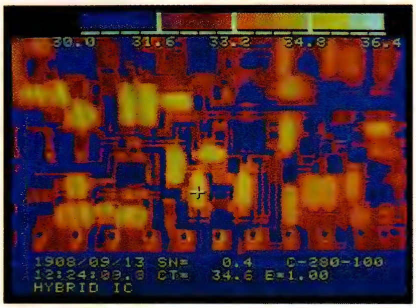

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CIRCLE NO 42

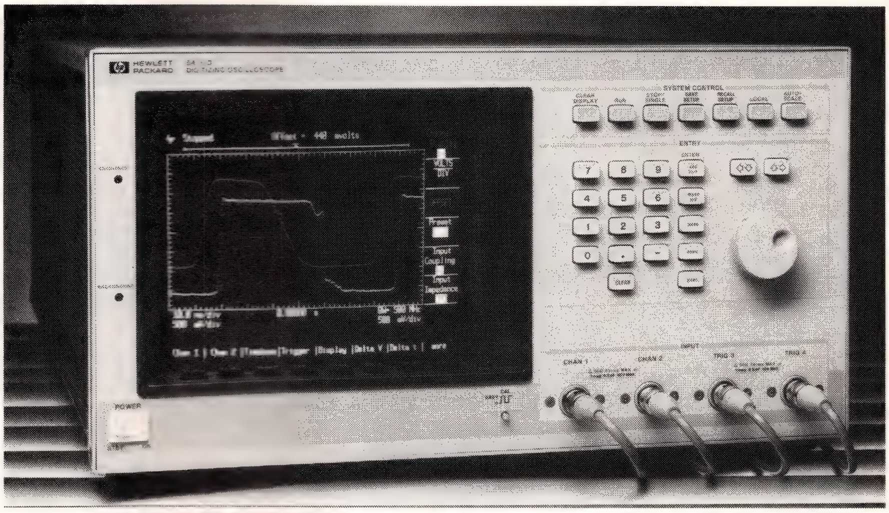
FFT program in the Model 3000's software package to display the input in the frequency domain. You can also split the screen to display the input signal in both the time and frequency domains at the same time.

S/N ratio equals resolution

Like the Sequence 3000, LeCroy's Century Series 2000 waveform digitizer captures only single-shot events. It has a 1.3G-sample/sec digitizing rate or, more precisely, a 741.84-psec sampling period—the fastest sampling rate available in a solid-state waveform recorder. The 8-bit A/D converter is built with bipolar and thick-film devices. The system's analog bandwidth is 250 MHz.

Instead of defining its effective resolution in terms of effective bits, LeCroy specifies the Century Series 2000's S/N ratio for a number of input signals. As an illustration, the S/N ratio for a 250-MHz, 400-mV p-p signal is 27 dB. This ratio translates to approximately 4.5 effective bits of resolution. For lower-frequency inputs—for example, a 5-MHz input—the S/N ratio improves to 35 dB, which equates to approximately 5.8 bits.

The Century Series 2000 is one of several waveform-digitizing systems based on the CAMAC standard. The crate, or instrument mainframe, includes the Model 6010 interface/controller and the Model 6880 waveform digitizer. Other slots in the mainframe accommodate additional digitizers or preamplifiers. Because the 6880 can digitize at only one sample rate, you may want to install one of LeCroy's other waveform recorders for slow signal acquisition. You can control the Century Series 2000 from its front-panel controls, a keyboard, a dumb terminal, or a PC/XT. The Model 6010 interface/controller generates its own composite-video output for any composite-video monitor.



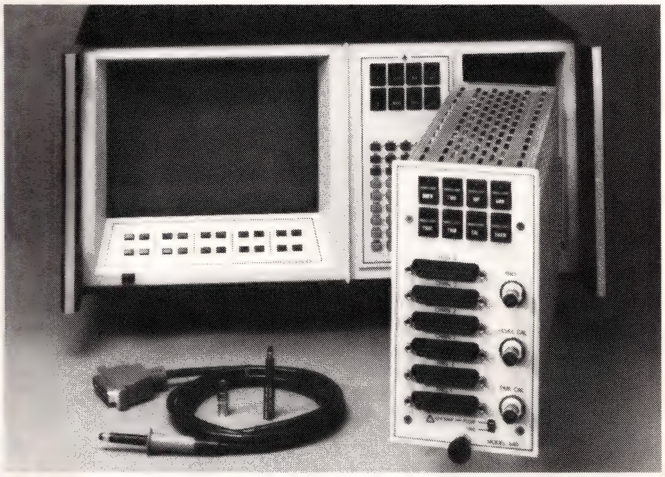
You can capture single-shot events to 250 MHz *and repetitive events to 500 MHz with Hewlett-Packard's 54111D digitizing oscilloscope. By filtering input signals, you can increase the effective vertical resolution of the 54111D's 6-bit A/D converter to that of an 8-bit A/D converter.*

The instrument stores digital data in a 10k-word memory. After each acquisition, it automatically corrects the data for dc gain, offset, linearity, and high-frequency bandwidth. It uses an internal 10-MHz square-wave reference and a series of 12-bit dc offset voltages to generate calibration coefficients. You initiate the calibration cycle with a front-panel command. The Sequence 3000's calibration procedure, on the other hand, operates automatically as a background task.

Good circuit design is one way to limit noise in a scope or waveform recorder; the use of filters is a sec-

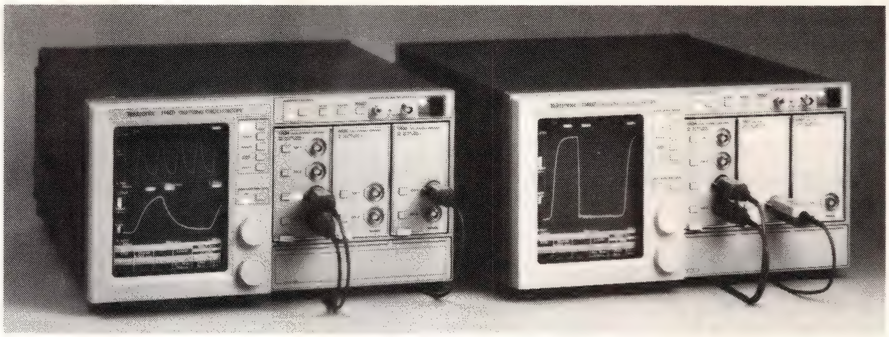
TABLE 1—RESOLUTION OF N-BIT A/D CONVERTERS

NUMBER OF BITS	RESOLUTION AS A FRACTION	RESOLUTION (dB)
2	1/4	−12.0
3	1/8	−18.1
4	1/16	−24.1
5	1/32	−30.1
6	1/64	−36.1
7	1/128	−42.1
8	1/256	−48.2
9	1/512	−54.2
10	1/1024	−60.2
11	1/2048	−66.2
12	1/4096	−72.2
13	1/8192	−78.3
14	1/16,384	−84.3
15	1/32,768	−90.3
16	1/65,536	−96.3



Repetitive 1-GHz signals resolve to 10 psec *when collected by Data Precision's Model 640 waveform-digitizer module. You can use the averaging routines found in the Data 6000 mainframe to increase the 16-bit digitizer's effective bit resolution.*

ond way. Filters limit the input bandwidth and thus reduce input noise and increase an instrument's effective bit resolution. LeCroy's Century Series 2000 has lowpass filters with cutoff frequencies of 150, 220, 270, and 300 MHz. Hewlett-Packard's 54111D 1G-sample/sec digitizing oscilloscope also has lowpass filters, with cutoff frequencies of 250, 100, and 25 MHz.

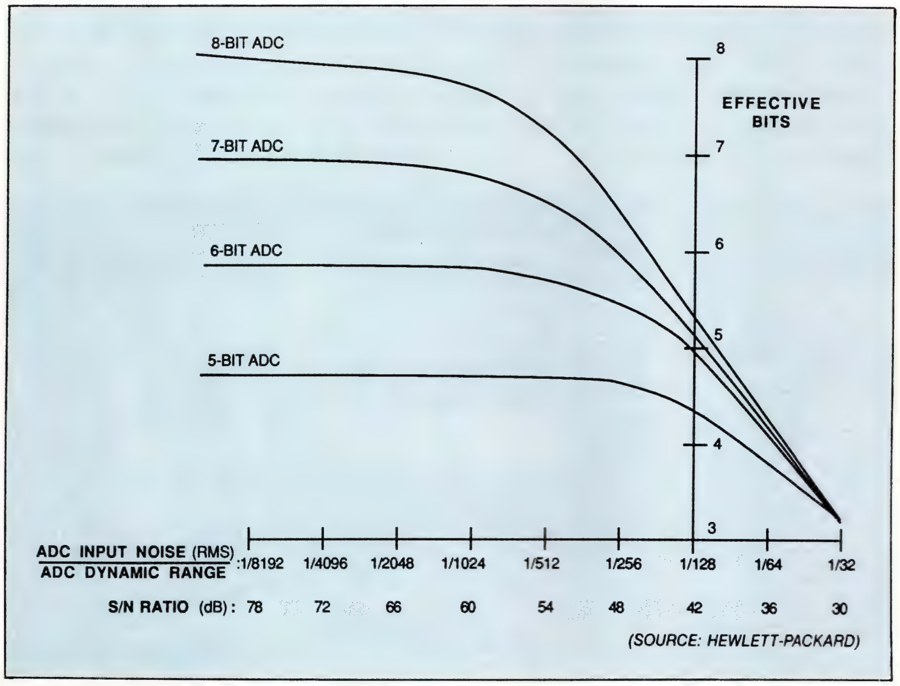


By averaging measurements, you can increase the effective vertical resolution *of the result to 14 bits on Tektronix's 11400 Series of oscilloscopes. The two models in the 11400 Series differ only in bandwidth: 500 MHz for the 11401 and 1 GHz for the 11402.*

The 54111D combines the advantages of a 1G-sample/sec waveform digitizer with those of a digitizing oscilloscope. You can take single-shot measurements with 1-nsec resolution on 250-MHz signals (four data points per cycle), or you can switch modes and take repetitive signal measurements on 500-MHz signals.

To achieve this level of performance in the 54111D, Hewlett-Packard combined a number of device technologies. The attenuator and preamp sections of the design use both thin-film and thick-film hybrids. The track/hold circuit employs gallium-arsenide technology. The time-multiplexed output of the track/hold circuit feeds four 6-bit bipolar A/D converters. Each A/D converter feeds a 1.7-µm Microgate NMOS memory. A 1-GHz SAW oscillator controls the NMOS timebase chip.

The filter used in the 54111D affects measurements in two ways. First, the filter is a digital oversampling unit that uses the data present in multiple quantizing, or Q, levels to resolve signals between the Q levels of the scope's 6-bit A/D converter. Second, the filter helps reduce overall system noise. Any reduction in the amount of noise in the oscilloscope will result in an improved S/N ratio, which translates to higher effective bit resolution.



(SOURCE: HEWLETT-PACKARD)

Fig 1—As the noise on an ideal A/D converter's input increases, *the converter's effective vertical resolution decreases. For noise levels below 1/8192, no converter detects the noise added to its quantizing noise level.*

When you calculate the effective bit resolution for an ideal A/D converter as a function of input noise, you would expect the number of effective bits to decrease as noise is added to the input. That is precisely what the curves in **Fig 1** show. For noise levels below 1/8192, or $1/2^{13}$, the value of the ideal A/D converters' full-scale ranges, none of the converters detects the noise added to its quantizing noise level. But as the input noise increases, the effective resolution of each of the ideal converters starts to tail off.

When Hewlett-Packard measured the effective bit resolution of the 54111D, it found that, as expected, the number of effective bits decreased as noise increased. But when an input filter was switched on, the number of effective bits increased as the cutoff frequency of the lowpass filter was reduced. With the 250-MHz filter on, Hewlett-Packard measured 5.25 effective bits. When the 100-MHz filter was engaged, the effective bit resolution increased to 6.25, and when the 25-MHz filter was on, the effective bit resolution increased to 7.25 bits.

Hewlett-Packard plotted the measured points against ideal A/D-converter curves like those shown in **Fig 1.** Because the measured points fall on the ideal curves, Hewlett-Packard uses the terminology "6-bit mode," "7-bit mode," and "8-bit mode" to describe the effective reso-

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lution of the 54111D. In other words, if you are using the 54111D with the 25-MHz filter engaged, for example, you will have the same effective bit resolution as you would with an ideal 8-bit A/D converter. But as you can see from the previous discussion, that does not mean you will have eight bits of resolution.

The Hewlett-Packard 54111D incorporates many of the measurement features found in the oscilloscopes of the 54000 family. The 54111D uses a color display, for which you can select seven colors of the 4096 colors available.

Because the 54111D uses a random repetitive sampling technique, it can capture and display pretrigger information in both the single-shot event mode and the repetitive event mode. For repetitive events, you can ask the scope to examine the incoming signal and automatically set the vertical scaling, offset, trigger level, and timebase controls.

Another feature of the 54111D exemplifies yet another way to improve resolution. For repetitive events, the 54111D can average the data from several acquisitions to reduce noise and increase the effective resolution of the scope.

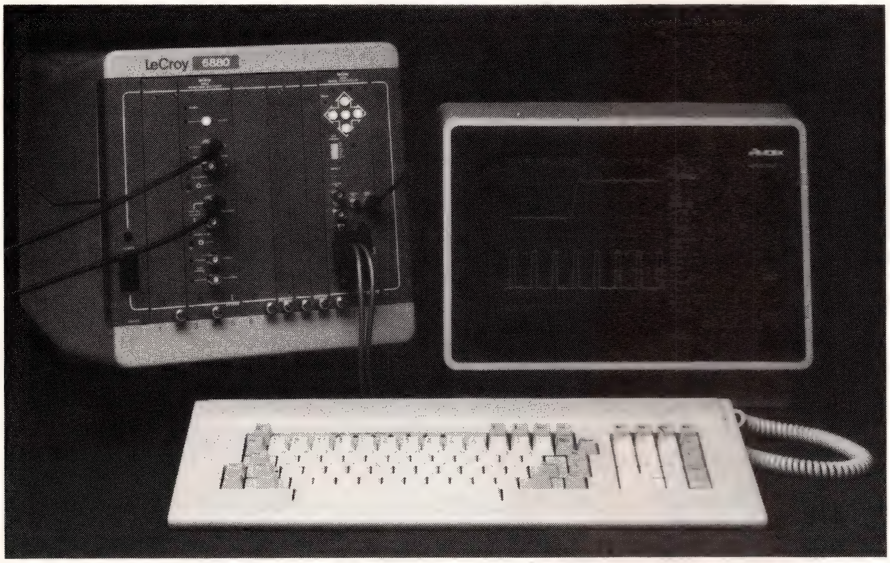
In general, when averaging, an instrument reduces the amount of noise riding on a repetitive waveform by a factor equal to the square root of the number of readings averaged together. For instance, if you average 256 measurements, the input noise level will fall by a factor of 16, which equates to an effective resolution improvement of four bits.

Data Precision's Data 6000 waveform analyzer can compute a running mean average and a final mean average on data collected by its 1-GHz, 16-bit waveform-digitizer module. This module, Model 640, uses a repetitive sampling technique to collect data. Its effective sampling rate is 100G samples/sec (a 10-psec sample period). Its analog bandwidth is 1 GHz, and the rise time is less than 350 psec. The module's settling time for a full-scale step input (settling to within 0.01% of its final value) is less than 10 nsec.

The 640 module has an input

TABLE 2—HIGH-PERFORMANCE DIGITIZING OSCILLOSCOPES AND WAVEFORM RECORDERS

COMPANY	MODEL	ANALOG BANDWITDTH (MHz)	NUMBER OF INPUT CHANNELS	MINIMUM VERTICAL DEFLECTION FACTOR (mV/DIVISION)	DUAL TIMEBASE	MAXIMUM DIGITIZING RATE (MEGASAMPLES/SEC)	MAXIMUM EQUIVALENT-TIME SAMPLE-MODE DIGITIZING RATE (GIGASAMPLES/SEC)	EQUIVALENT-TIME SAMPLE-MODE BANDWIDTH (MHz)	DIGITIZER RESOLUTION (BITS)	MAXIMUM EFFECTIVE VERTICAL RESOLUTION (BITS)	SAMPLE MEMORY (WORDS)
DATA PRECISION	DATA 6000/ 640	1000	2, EACH WITH 2 SWITCHED INPUTS	± 2.5V FULL SCALE	YES	N/A	100	1000	16	16	32k
HEWLETT-PACKARD	54111D	500	2	1	NO	1000	1	500	6	8	8k
LeCROY	CENTURY SERIES 2000	250	1 WITH 2 SWITCHED INPUTS	500 mV P-P FULL SCALE	NO	1300 (FIXED RATE)	EQUIVALENT–TIME SAMPLE MODE NOT AVAILABLE		8	8	10k
SEQUENCE	3000	350	1	50	NO	1000	EQUIVALENT–TIME SAMPLE MODE NOT AVAILABLE		10	10	1k
TEKTRONIX	11401/ 11A52	500	2	1	YES	20	100	500	10	14	10k
	11402/ 11A71	1000	2	10	YES	20	100	1000	10	14	10k



The 1.3G-sample/sec, 8-bit waveform digitizer *in LeCroy's Century Series 2000 instrument mainframe captures 250-MHz single-shot events with a timing resolution of less than 1 nsec. You can install additional Model 6880 digitizers in the mainframe.*

AUTOMATED MEASUREMENTS	WEIGHT (LBS)	BASE PRICE	COMMENTS
RMS, PEAK-TO-PEAK, MEAN, RISE TIME, PULSE WIDTH, FFT, CORRELATION, AND CONVOLUTION	30	$17,000 ($6895 FOR MODULE ONLY)	EACH OF THE FOUR SWITCHED INPUTS CAN CONTROL A 16-INPUT MULTIPLEXER
FREQUENCY, PERIOD, PULSE WIDTH, RISE/ FALL TIMES, PEAK-TO-PEAK, TOP- AND BASE-VOLTAGE LEVELS, PRESHOOT, AND OVERSHOOT	59	$23,900	COLOR DISPLAY
	43	$17,950 ($15,500 FOR MODULE ONLY)	MULTIPLE DIGITIZERS CAN FIT IN ONE INSTRUMENT MAINFRAME
MEAN AND FFT	40	$30,000	USES IBM PC/XT WITH COPROCESSOR TO CONTROL AS MANY AS EIGHT DIGITIZERS
FREQUENCY, PERIOD, PULSE WIDTH, RISE/ FALL TIMES, TIME INTERVAL, PEAK-TO-PEAK, MIN, MAX, MID, MEAN, RMS	44	$15,405	CAN DISPLAY EIGHT INDEPENDENT TRACES SIMULTANEOUSLY; TOUCH-SCREEN CONTROL WITH POP-UP MENUS
SAME AS MODEL 11401	44	$20,900	SAME CAPABILITIES AS 11401, BUT WITH INCREASED BANDWIDTH

range of ±2.5V. Theoretically, you could resolve inputs to less than 100 μV with the 16-bit converter, but the module has an 88-dB noise spec for a full-scale input, which translates to approximately 14.6 effective bits. You must call up the averaging routines on the Data 6000 mainframe to increase the effective resolution.

Tektronix's 11400 Series digitizing scopes also use averaging to increase vertical resolution. The 11400 Series consists of two models: the 500-MHz Model 11401, and the 1-GHz Model 11402. The units have identical features except for the bandwidth. They both use 20M-sample/sec digitizers and random repetitive sampling techniques to achieve a 10-psec horizontal resolution.

Each scope accommodates five plug-in units, the striking feature of which is the lack of front-panel controls. There are only one, two, or four buttons, plus input connectors, on the panels. You access most of the remaining controls via pop-up menus that appear on the instrument's touchscreen display. A scope can display eight independent traces simultaneously. Each trace has 10,240 data points.

The scopes' probes take advantage of the instruments' automatic-setup capabilities. You place the probe on a signal's test point and press a button on the probe. The scopes then automatically set the screen and triggering settings, take the measurement, and display the waveform. For automated measurements, you can select six measurement possibilities from a menu. The scope will then display the selected values and continuously update them.

You also use a pop-up menu to program the number of measurements to be averaged when you select that option. According to the company, you can achieve 14-bit effective resolution through averaging. The 11400 Series scopes have 10-bit A/D converters; to achieve

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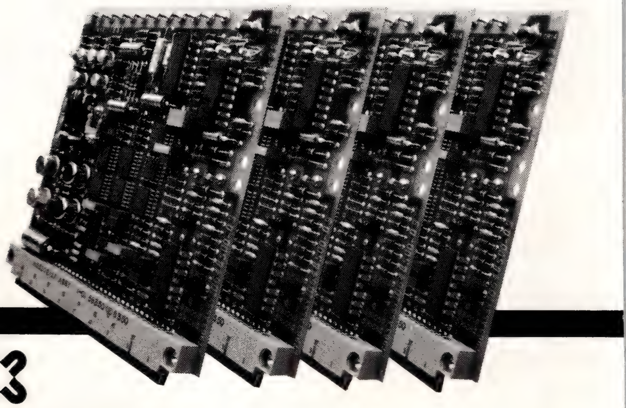

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Tektronix Inc
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Beaverton, OR 97077
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TABLE 3—RESOLUTION IMPROVEMENT VS NUMBER OF AVERAGES

NUMBER OF AVERAGES	NOISE IS REDUCED BY A FACTOR OF . . .	RESOLUTION IMPROVEMENT (NUMBER OF EFFECTIVE BITS)
4	2	1
16	4	2
64	8	3
256	16	4
1024	32	5
4096	64	6
16,384	128	7
65,536	256	8

higher than 10-bit resolution, your input signal must have at least 1 LSB of noise riding on it. The noise causes the actual data point to appear in two or more Q levels on successive measurements. Then, when the measurements are averaged, the instrument can resolve the resulting data points to greater than 10 bits.

For the ideal situation, then, you need to average 1024 measurements to increase the scopes' resolution from 10 bits (actually, from nine bits, because of the need for 1 LSB of noise) to 14 bits. In reality, the 11400 Series scopes' effective resolution is below nine effective bits.

Although you won't find the terms "effective bits" or "S/N ratio" on the 11400 Series data sheet, you can use the data sheet's typical noise specs for the plug-ins to make a best-case calculation of the scopes' effective bit resolution. For the 600-MHz, 2-channel 11A52 plug-in, the effective resolution varies from 5.2 bits on the 1-mV range to 7.9 bits on the 10-mV to 1V ranges. For the 1-GHz, single channel plug-in, the effective resolution is 8.7 bits on all ranges. **Table** 3 gives the number of measurements that must be averaged to achieve a given effective resolution.

Today's oscilloscopes and waveform recorders now have the technical capability to let you make many of the measurements you're likely to need. Techniques are available to increase the vertical resolution of these instruments. Now all you need is some falling prices. **EDN**

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1. *Analog-Digital Conversion Handbook*, by the engineering staff of Analog Devices Inc, Prentice-Hall, Englewood Cliffs, NJ 1986.

2. *Feeling Comfortable With Digitizing Oscilloscopes*, Book Part Number 9320-5776, Hewlett-Packard Co, Palo Alto, CA, 1986.

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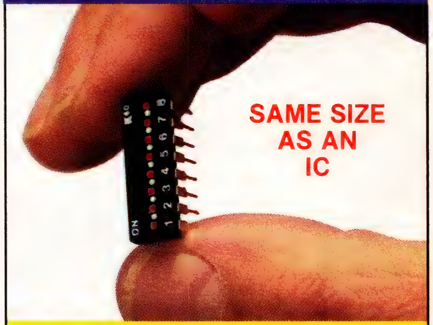

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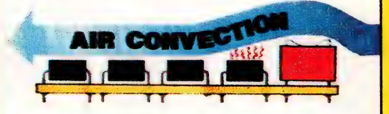

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CIRCLE NO 44

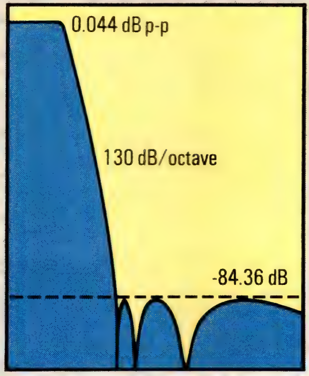
Friendly new 1 MHz filter

We have a tradition of leading the way to higher frequency filters.

Now, we announce the industry's first 1 MHz bandwidth filters for programmable use. 80 dB/octave attenuation. Time delay superior to Bessel. It's the friendly advance you've asked for.

New friendly elliptics as sharp as 130 dB/octave

Precision was first to offer elliptics with 80 dB/octave attenuation. Now, we're first to add the sharper option of 130 dB/octave for frequencies up to 255 kHz.



Passband ripple is 0.044 dB p-p, and there's 1° phase match up to the cutoff frequency.

Filters are offered in a wide variety of types that you can mix or match within the 16 card capacity of the new Precision 6000 mainframe. Filters come one, two or four channels per card, depending on resolution and other performance features.

Friendly is extending your choice to match needs and budget precisely.

New friendly open door policy on configuration

Not only can you mix various types of filters, you can also add a variety of preamps, postamps and gain-ranging amplifiers, as well as frequency band translators. And to that, you can soon add such input conditioning as strain, charge and voltage.

It's a simple matter to select the hardware building blocks. It's simple to configure their control for convenient operation. It's also simple to modify and add to your system as requirements change.

The Precision 6000 starts system friendly and stays system friendly.

WORLD'S FIRST SYSTEM FRIENDLY CONDITIONERS

Now, you can integrate filters, amplifiers, frequency band translators and other signal conditioners *your* way in *your* system about any way *you* wish. You can do it as never before. We've gone beyond user friendly and created system friendly. That's new Precision 6000.

Now, custom systems at friendly off-the-shelf prices

Yesterday's custom systems are configured with today's standard hardware and software. Yesterday's unaffordable becomes very affordable today. Tomorrow's new instruments will operate in today's mainframe. That's system friendly with futures.

Friendly language brings down old barriers

No longer do you have to be concerned about the programming idiosyncrasies of a number of instruments. All Precision 6000 asks is familiarity with a few basics.

You set up from the Precision 6000 front panel with prompting and cuing from its program. You string your set-ups together for the test routine required. One command uploads set-ups to the host computer.

Friendly is letting you all but forget programming, so you can concentrate on measurement problems.

More innovation from the leader

We're adding all the advances announced here to the features Precision has introduced over the last decade. 80 dB/octave attenuation, time delay superior to Bessel, 1° phase match, choice of serial, parallel or GPIB computer interfaces, for example. That's system friendly indeed.

Call friendly 607-277-3550.

Call for all the details on new Precision 6000.

Let us send you our people's best friend, a dog with a magnetic back to remind you how system friendly conditioners can now be. Telex 646846. Or write.

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240 Cherry Street, Ithaca, New York 14850

CIRCLE NO 46

HALF A GIGABYTE ISN'T

Introducing the world's first half-gigabyte 8" HSMD Winchester. Available now for evaluation.

As you'd expect from a world-class supplier, the Toshiba MK-288FC is designed around evolutionary technology. For maximum reliability.

Our new 8" Winchester puts 510MB into one-fourth the space of a 14" drive or half the space of a 9" drive, setting a new standard in space efficiency and cost per megabyte.

The higher capacity is made possible by the use of 8 disks and 15 heads. Yet the drive still fits in the industry-standard form factor. So you can put 2 gigabytes in a standard rack-mount drawer. Or 1 gigabyte in a half-height drawer.

Because we understand that you don't want to redesign your controller *again*, we didn't change the data transfer rate from 2.4MB/s. And if you don't need 510MB just yet, there's our plug-compatible 374MB model with 6 disks and 11 heads.

Both models in the new MK-280FC Series feature 18ms average access time, the high-speed SMD interface, and a center-stack servo for the last word in data reliability.

For entry-level systems, our MK-180 Series offers capacities of 83, 116 or 166MB with SMD interface and the same fast 18ms access time. Whatever your 8" Winchester requirements, we have world-class solutions.

All of which come with world-class support. Evaluation units when and where you need them. Technical assistance at your location. And a broad line of highly reliable products. From our 3½" and 5¼" floppies to 5¼" and 8" Winchesters and a range of optical storage products.

For complete information, call 408-727-3939. Or write Toshiba America, Inc., Disk Products Division, 3910 Freedom Circle, Suite 103, Santa Clara, CA 95054.

We'll show you how a truly world-class drive can put a lot more data into a lot less space.

**A fraction of the size.
A fraction of the cost.**

WORLD-CLASS QUALITY.
WORLD-CLASS SUPPORT.

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WHAT IT USED TO BE.

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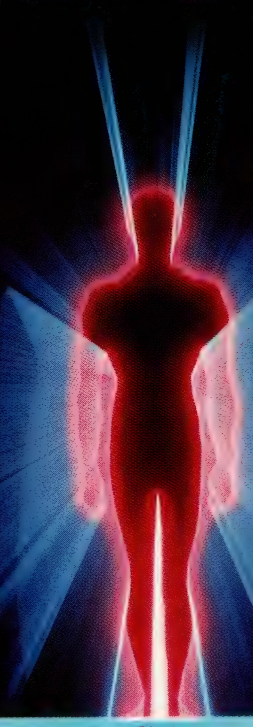
CIRCLE NO 47

Superior Electric gives today's motion control the feel of the future with its completely new family of step motor drives and programmable motion controllers—THE SLO-SYN® MICRO SERIES.

superior innovation in
MOTION CONTROL



Micro size. Here are the smallest, most powerful step motor drive modules available today. Optically isolated and designed for top efficiency, these chopper drives are rated 2A and 3.5A per phase, 30VDC, 20kHz.

Micro processor based, data-driven programmable preset indexers and motion controllers use industry standard machine tool language RS274 X, G and F codes for maximum application flexibility. Program storage up to 400 lines, 2 programmable inputs, 2 programmable outputs and overtravel limit switches. Provide RS232C interface, parallel switch interface and PLC operating mode. Up to 99 units can be daisy chained.

Micro stepping AC line operated step motor drives of the 3180 Series are available with either 1/125 or 1/10 microstep as well as full and half step. An innovative current control method assures smooth operation over a broad range, outperforming other drives on the market. And at lower cost.

For detailed product specifications and to arrange for an engineering test sample, write to The Superior Electric Company, 383 Middle Street, Bristol, CT 06010. For immediate action, call 203/582-9561.

CIRCLE NO 48

Superior Electric
The right amount of automation.

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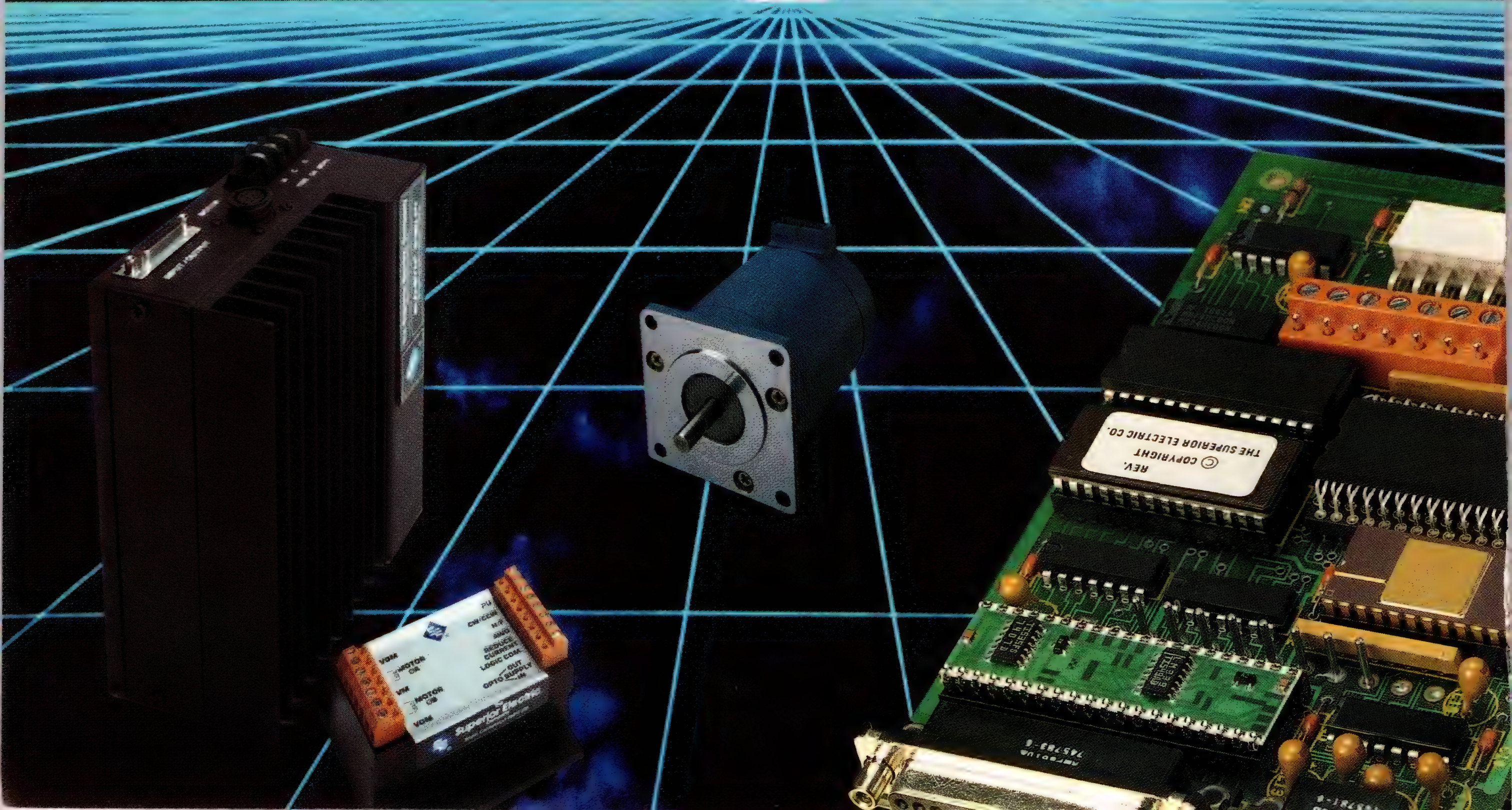

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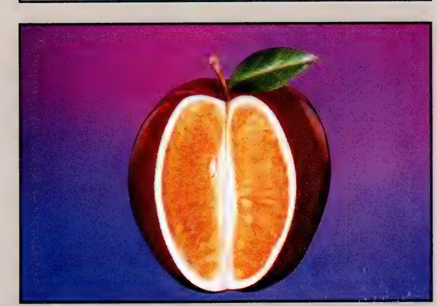
An exciting, highly advanced concept in power supply design!

DCR-T Series High-Power, 3-Phase Input, Laboratory/Industrial Power Supplies with Built-in OVP



Remote-controllable DC safety and flexibility th

DCR-T represents a significant departure from, and vast improvement over, conventional power supply design. As a result, the DCR-T is without equal.

DCR-T is the most powerful 10-kW unit you can buy.

We designed the DCR-T to suit more applications by providing more convenient voltage ranges and substantially more current than other supplies. That's why **the DCR-T gives you the additional current you need, without forcing you to pay for a larger, more expensive, higher-amperage unit.**

For example, if you need 600 amps at 14.5 Vdc, a conventional 10-kW, 20-volt unit just won't do – it provides only 500 amps. In the past, you had to buy a much more expensive, 20-kW supply.

But, our new 16-volt, 10-kW DCR-T Supply delivers a whopping 625 amps – a full 25% more current than typical 20-volt, 10-kW units!

That's why you can count on Sorensen for more current at lower cost, in the industry-standard, compact package!

The DCR-T is easier to use.

Every DCR-T is fully remote-controllable via resistance, voltage or IEEE-488 programming to meet the demands of today's sophisticated burn-in and process applications. **While other supplies can remotely control only voltage and current, the DCR-T also lets you program OVP and shutdown.** Even all indicators and meters on the DCR-T can be used for remote readout.

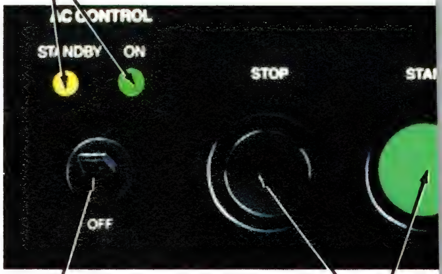
The DCR-T Series is not like any other power supply.

It is not like any other in appearance or electrical and mechanical design. For example, the sensing and programming controls on the DCR-T have been completely separated from each other to make them completely non-interactive. As a result, **the programming controls can be placed any distance from the load,** allowing operation of the DCR-T from most anywhere.

The DCR-T is safer and more reliable.

Separating the sensing and programming functions gives the DCR-T another major advantage over all conventional power supplies. **The DCR-T's programming resistors are never subjected to the output voltage, completely eliminating the possibility of voltage breakdown across its programming components.**

The DCR-T is available with standard analog, or optional digital meters at no extra cost. Units without meters are available at reduced cost.



STANDBY/ON INDICATORS–
Show whether the DCR-T
is in standby or
operational mode

STANDBY SWITCH–
Energizes all controls
in "ON" position without
turning on main power

STOP/START
PUSHBUTTONS
Switch main pow
on or off

DCR-T prevents burn-ins from becoming burn-outs!

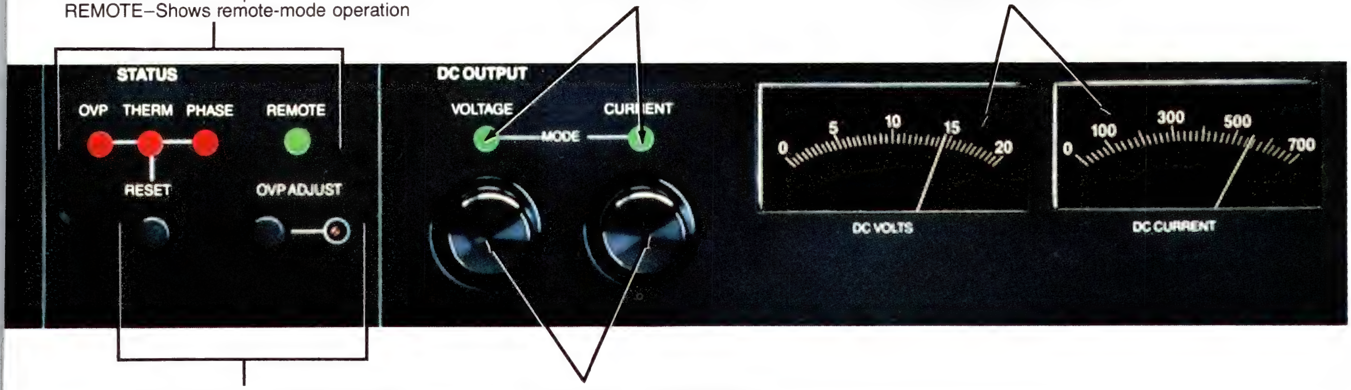
On other power supplies, even those with OVP, when remote programming lines open, the output surges to maximum unregulated voltage and/or current, often burning out the product under test. **But, the DCR-T's special safety circuit reacts instantly to such open conditions, preventing the dc output from going out of control.**

-T provides greater power, n conventional supplies.

OVP–Shows overvoltage protection has tripped
THERM–Indicates over-temperature
PHASE–Warns of ac power-line loss
REMOTE–Shows remote-mode operation

INDICATORS–Show whether unit is in constant VOLTAGE or CURRENT mode

METERS–Provide output readings of VOLTAGE, CURRENT and OVP LEVEL



RESET–Return to normal after fault
OVP ADJUST–PUSHBUTTON lets you read OVP level on DC VOLT METER
SCREW POT sets OVP level

DC OUTPUT CONTROLS–Set VOLTAGE and CURRENT output

The DCR-T has unique, 2-level overvoltage protection.

Built-in OVP with ac shutdown is included at no extra cost. Providing greater safety than many optional OVPs, our standard OVP has an inhibit mode, plus standby, which removes the main power from the transformer. An optional OVP SCR crowbar can be added.

There's a DCR-T perfect for most any application.

Offering unheard of flexibility, the DCR-T will be available in nine 10-kW models in 1986, in 0-8 Vdc to 0-600 Vdc, and 16 Adc to 900 Adc. In addition, 5-kW and 2.5-kW DCR-T Supplies are currently under development. All DCR-T models are thyristor-controlled and dc-regulated. 480-Vac, 60-Hz, three-phase input is standard; 380-Vac, 50-Hz is optional.

DCR-T prices* and options.

● Models with analog meters	**$3,900**
● Models with digital meters, add suffix M50 to Model Number	**$3,900**
● Models without meters or voltage and current controls, add suffix M51 to Model Number	**$3,800**
● To order optional SCR Crowbar, add suffix M5 to Model Number	**$ 200**

* Manufacturer's Suggested List Price

Model	Voltage (Vdc)	Current (Adc @ 50°C)	Regulation[1] Voltage (mV)	RMS Ripple Voltage (mV)	Transient Response (ms)
DCR 8-900T	0-8	900	4-8	30	40
DCR 16-625T	0-16	625	8-16	30	40
DCR 32-310T	0-32	310	16-32	20	40
DCR 55-180T	0-55	180	27-55	20	40
DCR 80-125T	0-80	125	40-80	20	40
DCR 110-90T	0-110	90	55-110	40	40
DCR 160-62T	0-160	62	80-160	60	40
DCR 300-33T	0-300	33	150-300	100	40
DCR 600-16T	0-600	16	300-600	150	40

All models are case size III, 19″W x 24″D x 12¼″H. Weight 310 lbs.

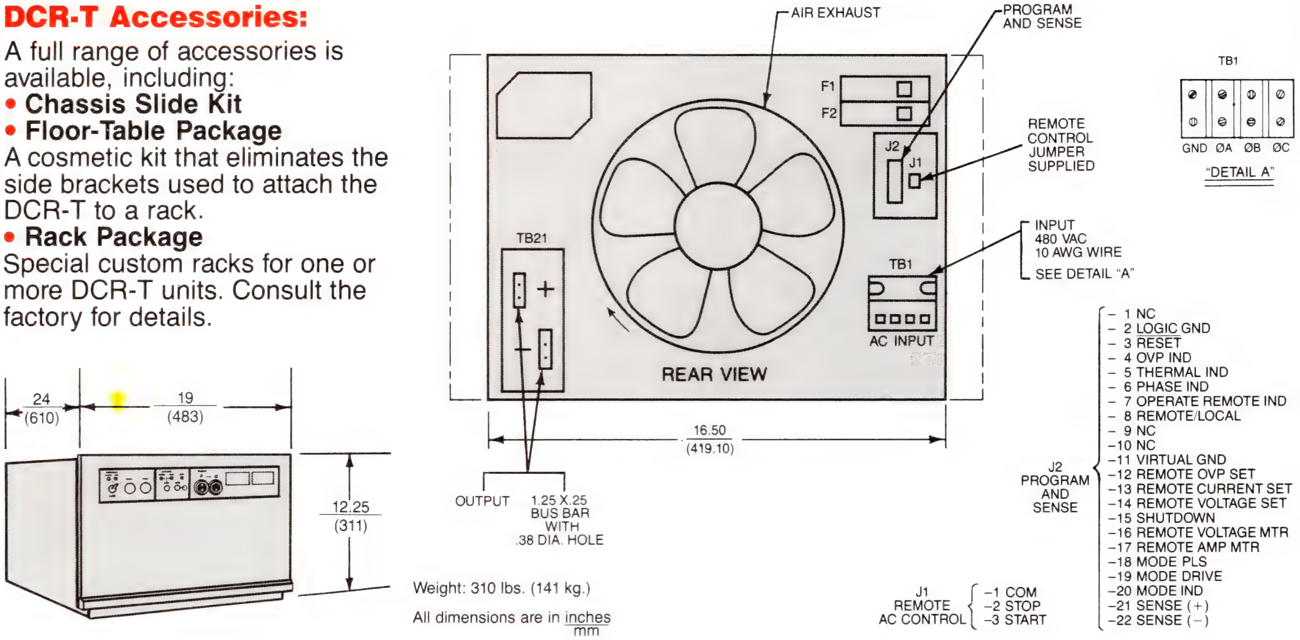
1. Regulation range as stated 0.1% of voltage, or stated range, whichever is greater.

Sorensen
A **Raytheon** Company

DCR-T Accessories:

A full range of accessories is available, including:

- **Chassis Slide Kit**
- **Floor-Table Package**
  A cosmetic kit that eliminates the side brackets used to attach the DCR-T to a rack.
- **Rack Package**
  Special custom racks for one or more DCR-T units. Consult the factory for details.



Weight: 310 lbs. (141 kg.)

All dimensions are in $\frac{\text{inches}}{\text{mm}}$

FREE Catalog of over 400 power instruments.

In addition to the DCR-T Series, Sorensen produces a full line of off-the-shelf and semi-custom power supplies as well as custom power supply assemblies, for laboratory/industrial and OEM users. Sorensen's latest Full-Line Catalog provides over 100 pages of valuable engineering information and specifications on all models. It includes the Sorensen linear, phase-controlled, and switching power supplies as well as the XT Series of fast, programmable 60-watt linears, and IEEE-488 listener/talker programmers. Contact Sorensen for your FREE copy today!

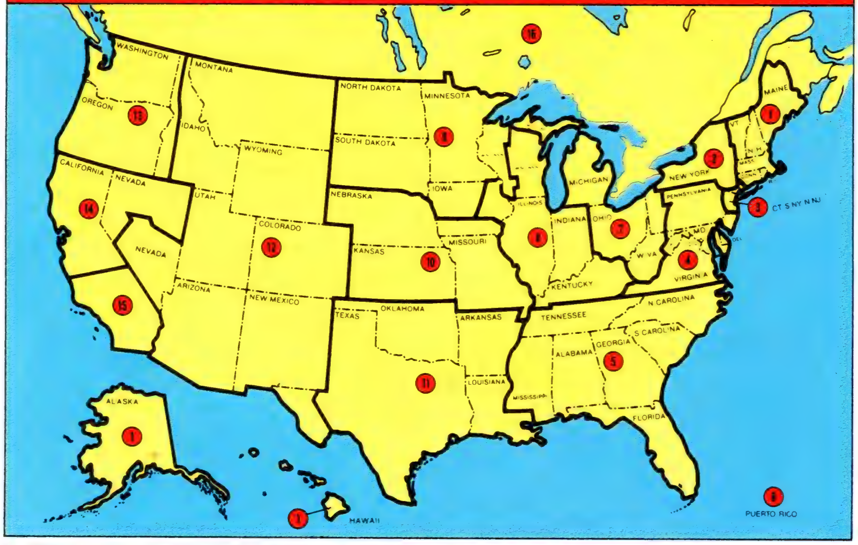
Sorensen—the first name in power supplies.

No other manufacturer can match Sorensen's experience in power supplies! Founded in 1943, Sorensen was the first commercial firm to manufacture and market precision electronic voltage regulators and power supplies. Over the last 43 years, our reputation for dependability, value and performance has been second to none—because our commitment to excellence has never wavered.

Sorensen—built and backed better.

Sorensen Power Instruments are built tough, and designed to last. That's why **we back them with our strong limited parts and labor warranty for up to 5 years!** See our catalog for warranty details on all models.

SORENSEN REPRESENTATIVES



AREA	REPRESENTATIVE	TELEPHONE
1	Sorensen Company	603-668-4500
2	TAE-REP, INC.	607-692-3705
3	Crane & Egert (CT, Fairfield County) (S.NY, Long Island) (N.NJ)	516-872-0800
4	SCI-REP, INC. (DC, W.VA, VA, MD) (S.NJ, E.PA, DE)	703-385-0600 609-662-5222
5	Currie, Peak & Frazier (FL) (AL, MS) (TN) (GA, SC) (NC)	305-855-0843 205-536-1506 615-459-0743 404-449-7662 919-373-0380
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16	Allan Crawford Associates, Ltd. (Canada)	416-890-2010

Contact your nearest Sorensen Representative for additional information, a fast price quote, free Full-Line Catalog, or to place an order. To contact Sorensen directly, call (603) 668-4500.

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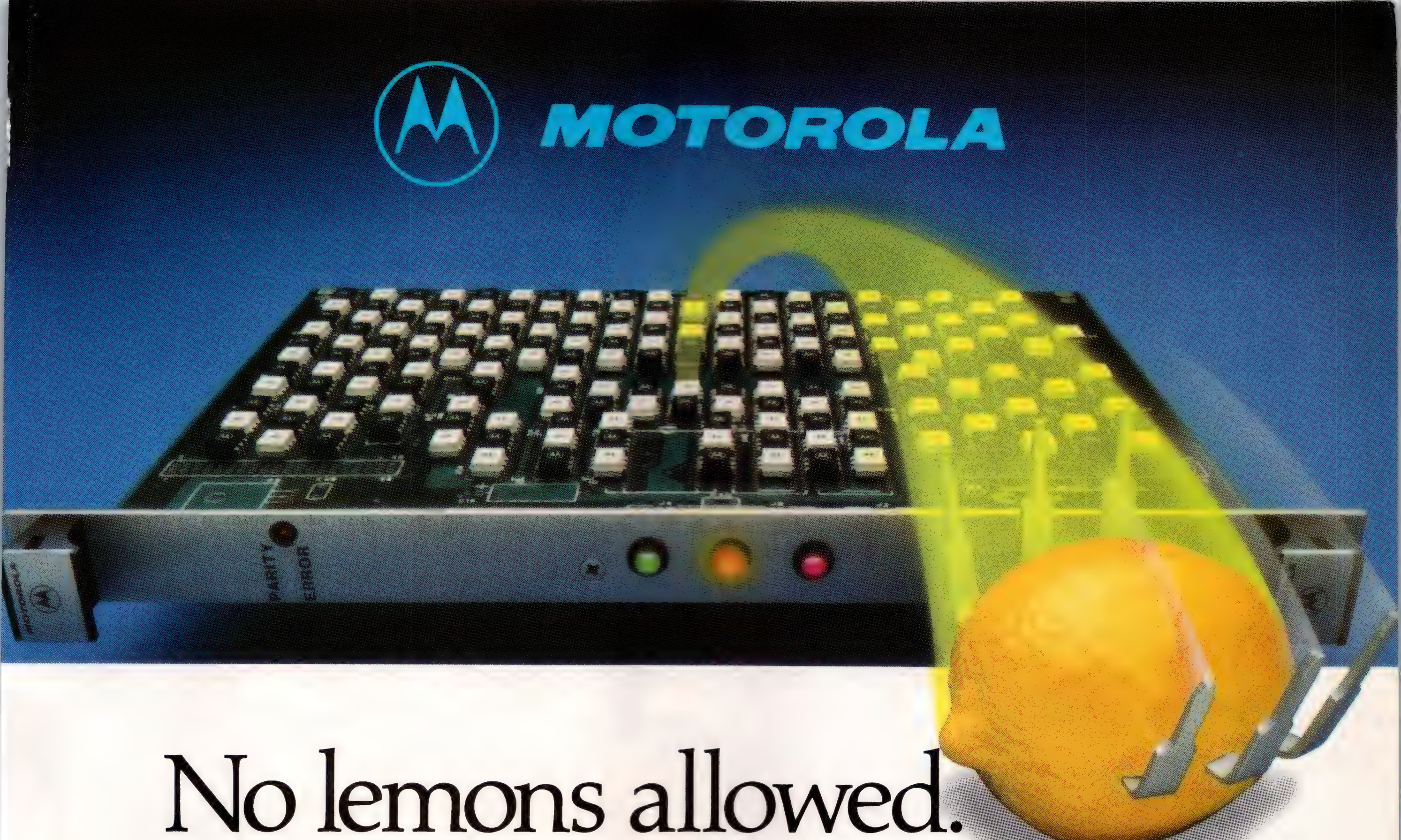

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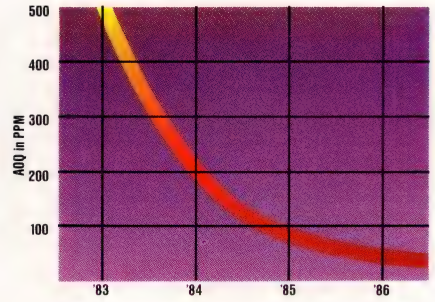
That's how much confidence we've got in our entire line-up of high-quality, high-reliability optoisolators.

The same confidence you can feel when you design them in.

Motorola optoisolator AOQ. Guaranteed 50 PPM.



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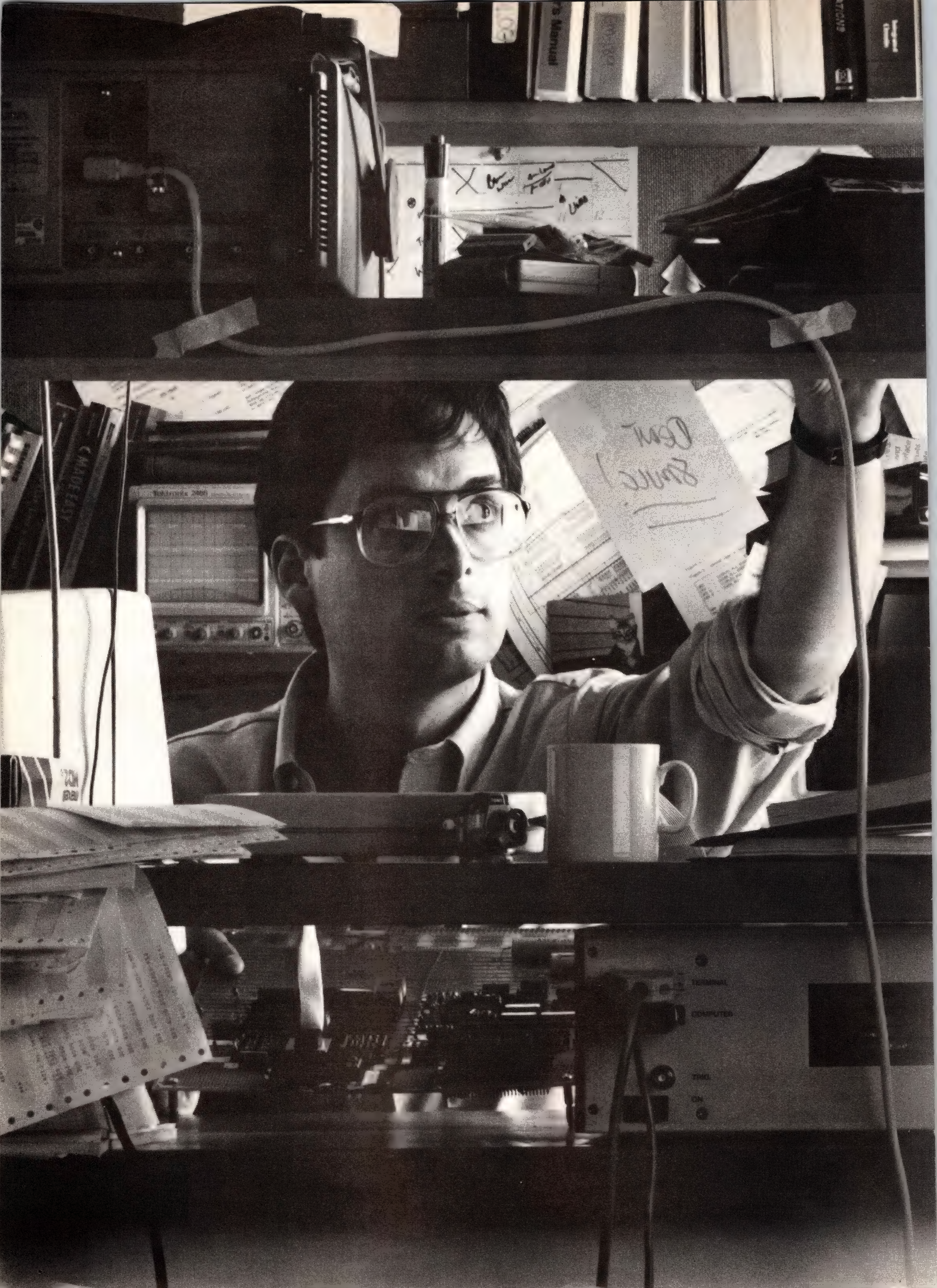
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The difference between a few more tweaks and a few more weeks.

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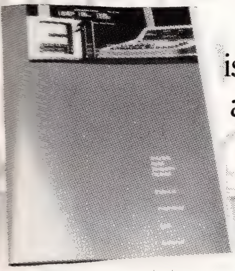
CIDS stands for Customer Integrated Development Systems and the concept is simple. You choose your hardware and software tools. Applied Microsystems makes sure they work together seamlessly.

An overview of Customer Integrated Development Systems.

Whether you're working on an 8-bit, 16-bit or even a 32-bit design, we let you tailor the emulation and debug tools you need. Everything from symbolic and source-level debuggers to assemblers, cross-compilers and utilities. The chart gives you some idea of the power and convenience of the CIDS method, but it can only hint at the control and visibility you will enjoy.

Validate™ links emulation with source-level debugging.

When your software engineers only speak C and your emulator only speaks assembler, your tools are worthless. Or if your function is in assembler and your debugger only speaks C, it's the same dead end.



The power of the Validate environment is that it works equally in high level languages and in assembler. You don't sacrifice any power or comfort.

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Applied Microsystems lets you emulate high performance targets at top speed. Up to 16.6 MHz for the 68020. And 12.5 MHz for our new 80286 with full function implementation. Free access to the virtual protect mode makes transparent emulation possible using logical or physical addresses.

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Discover why the CIDS method is the fastest, easiest way to start and finish a design project. For technical and application details call 1-800-426-3925. In Washington state call (206) 882-2000. Or write Applied Microsystems Corporation, P.O. Box 97002, Redmond, WA 98073-9702.

In Europe: Applied Microsystems, Brooke House, Market Square, Aylesbury, Buckinghamshire, HP20 1SN, England. Tel: 44 (0296) 34822.

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CIRCLE NO 49

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Modern stepper-motor systems provide precise position control and resolution

Tom Ormond, *Senior Editor*

Over the years, stepper-motor-based position-control systems for the most part have been relegated to lower-performance applications. For high-performance position control, designers turned to servo systems. Now this situation is changing. In addition to an inherent ability to accurately control position, today's stepper motors are taking advantage of new microstepping-drive techniques and the resulting higher resolution to find increased use in computer-peripheral and industrial-robotic applications.

As the name implies, stepper motors respond to a pulse-type input by moving in predetermined incremental steps. In general, stepper motors offer designers a number of advantages. They are inherently digital, essentially maintenance free, and offer high torque per package size. Step error is noncumulative, and repeated stalling doesn't damage the motor. Finally, stepper motors are compatible with open-loop operation so position-control system designs are fairly straightforward.

On the other side of the coin, standard stepper motors suffer from some intrinsic shortcomings. Resonance is a major problem, as is ringing. Operation at low speeds is rough. Further, a standard 1.8° full-stepper motor's resolution is only 200 steps/revolution. Half-stepper motors increase resolution to 400 steps/revolution—still not a very impressive figure.

Perhaps due to these inevitable tradeoffs, stepper motors have until now taken a secondary position when compared with servo systems. Fortunately, new microstepping-drive techniques solve some of the stepper motors' problems and offer them a chance to become more competitive.

Substituting a thin samarium cobalt disk in place of the traditional iron rotor, *USS75 Series stepper motors from PMI Motion Technologies feature theoretical acceleration figures reaching 131,000 rad/sec.*

Microstepping techniques use electronic proportioning to divide a stepper motor's fundamental step angle into smaller sub steps: steps/step. By definition, microstepping involves more than 2 steps/step. Today, you'll find microstepping drives that can quantize the full-step pulses into as many as 125 steps/step. These types of drives use both phases of the motor continuously, applying currents in sine-cosine ratios.

The most obvious benefit that microstepping provides is improved positioning resolution. For instance, a 200-step/revolution motor with a 32-step/step microstepping drive can achieve 6400 steps/revolution. Actual resolution performance, however, will depend on the characteristics of the motor.

Microstepping confers other advantages in addition to resolution. It also reduces torque ripple, which is important in many constant-speed applications where the stepper motor operates as a brushless synchronous motor.

Eliminate resonance

Third, microstepping solves the problem of resonance. A stepper motor has a low natural frequency in the 150- to 250-Hz range, and when operating within this range, full-step input pulses can often cause the stepper motor to lose position, stop, or even reverse direction. Dividing the full step pulses into smaller microstepped increments totally eliminates the resonance problem in most cases.

Both rotary and linear stepper motors are capable of making use of

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CARLINGSWITCH
INNOVATION BY DESIGN

CIRCLE NO 82

microstepping-drive techniques. PMI Motion Technologies' Syncrostep family of rotary motors eliminates the massive iron rotor found in conventional rotary-position-control designs and substitutes a thin disk of samarium cobalt that is permanently magnetized in an alternating pattern of north and south poles.

This disk rotor fits between two independent sets of C-shaped stator laminations. Each set, with its electrical coil, makes up one phase of the motor. The two sets of laminations are offset from each other by one-half a rotor pole. When the input drive energizes phase A and the rotor aligns itself with the poles of the phase A laminations, the rotor is then in an intermediate position with respect to phase B. The input drive turns off phase A and turns on phase B, and the rotor advances to align with phase B.

By thus alternately energizing the two phases (and reversing their polarity), the drive input produces step motion. Actually, this mode of operation doesn't develop much torque. To achieve greater torque the drive input energizes both phases simultaneously, and the motor usually operates this way in most applications.

Because of their thin disk rotors, Syncrostep motors are much smaller and lighter than conventional stepper motors and servo systems with the same output ratings. The use of such disks also results in low inertia, which, combined with the high energy density of the rare-earth rotors, produces a high torque-to-inertia ratio.

Lower losses are possible

In addition, the absence of iron in the rotor's armature minimizes eddy-current losses. These lower losses can significantly reduce input power requirements. In conventional iron-rotor stepper motors, saturation occurs quickly as the current rises above rated levels. When you triple current, theoretically you expect to triple torque. Unfortunately, the torque increase varies from 25 to 75%.

Using a magnetic structure optimized to reduce losses, *MH Series motors from Superior Electric provide stepping rates to 20,000 pulses/sec when operating with half-step drives.*

Syncrostep motors offer far better response to current increases, having low-saturation characteristics similar to those of dc servo systems. The ability to boost current temporarily to produce higher-than-normal torque is important in applications where you might need to enhance acceleration (or deceleration) or handle temporary overloads.

The USS75 Series is representative of the Syncrostep family. USS75M units are optimized for microstepping and cost $245. Special design techniques produce virtually sinusoidal step-to-step torque-displacement characteristics, eliminating the need to compensate for harmonic distortion problems. Step angle, step accuracy, and typical holding torque are 1.8°, 5%, and 100 oz-in., respectively. Respective detent and friction torques measure 3 and 2 oz-in. The series specs a theoretical acceleration of 94,000 rad/sec^2 and a rotor inertia of 1.75 oz-in.-sec$^2 \times 10^{-3}$. Continuous output power is 80W max, and peak power rate is 110 kW/sec.

USS75S 1.8° step-angle motors cost $240 and also guarantee a step accuracy of 5%. With two phases fully energized, they claim a holding torque of 140 oz-in. typ (230 oz-in. pk). Detent torque and friction torque are 12 and 3 oz-in., respectively. These units furnish maximum continuous output power (using 8×16×0.375-in. aluminum heat sinks) of 125W. Peak theoretical acceleration equals 131,000 rads/sec, and rotor inertia equals 1.75 oz-in.-sec$^2 \times 10^{-3}$. The USS75S Series' peak power rate is 213 kW/sec.

Superior Electric also manufactures rotary-type units, but they differ from PMI's in several ways. Specifically designed for operation with bipolar chopper drives, MH Series Slo-Syn stepper motors provide the power needed for machine-tool and other applications requiring high torque. Prices range from $650 to $900. The motors are capable of withstanding as much as 2.5 times rated current without any resulting demagnetizing. And they are designed to meet all applicable requirements of UL, CSA, and VDE.

A number of design features enhance performance. To reduce losses, for example, the motors'

***Available in NEMA-23 and -34 frame sizes,** R Series motor from Parker-Hannifin feature standard resolutions of 25,000 steps/revolution and linear forces of 25 to 400 lbs.*

magnetic structure employs low-loss steel and high-energy magnets in the rotors. According to the manufacturer, motor torque values are typically 10 to 100% higher than competitive units. And, the motors are capable of attaining stepping rates as fast as 20,000 pulses/sec (half-step mode).

All MH Series motors have high temperature insulation throughout (class F or better) for operation at higher duty cycles. Each motor has eight terminals, which can accommodate either series or parallel operation, and terminal-board construction simplifies input wiring.

Current ratings span 7.1 to 14.1A per phase for MH112-FJ8020 versions and 10.6 to 21.2A for MH112-FJ8030 units. Holding torque is 1980 oz-in. at rated current and 2620 oz-in. at two times rated current. The MH112-FJ8020 units spec a pull-out torque of 1630 and 1130 oz-in. at 2000 and 4000 pulses/sec, respectively. Residual torque is 100 oz-in. The -FJ8030 versions' pull-out torque is 1680 and 1620 oz-in. at 2000 and 4000 pulses/sec, respectively; their residual torque is 100 oz-in. For all these models, step angle equals 1.8°, and step-angle error and step-position error (at rated current) are both ±2%.

The MH172-prefix motors have per phase current ratings spanning 10.6 to 21.2A (-FD8030 versions) and 14.4 to 28.8A (-FD8040 models). Holding torque equals 5600 oz-in. at rated current and 7700 oz-in. at two times rated current. The -FD8030 versions claim a pull-out torque (at 2000 and 4000 pulses/sec) of 4400 and 3200 oz-in. Residual torque measures 300 oz-in. For the -FD8040 models, pull-out torque is 4390 and 3210 oz-in. (2000 and 4000 pulses/sec), and residual torque is 300 oz-in. At rated current, step-angle errors and step-position errors are both ±2%.

Moving straight ahead

Of course, not all applications involve rotary position control. Linear stepper motors are well suited to motion-control applications involving high-speed, low-mass moves. They preclude the need for cumbersome mechanical devices to translate rotary motion to linear because the motor provides the linear motion directly with one moving part, called the forcer. A linear motor isn't subject to the linear velocity and acceleration limitations inherent in most rotary-to-linear systems.

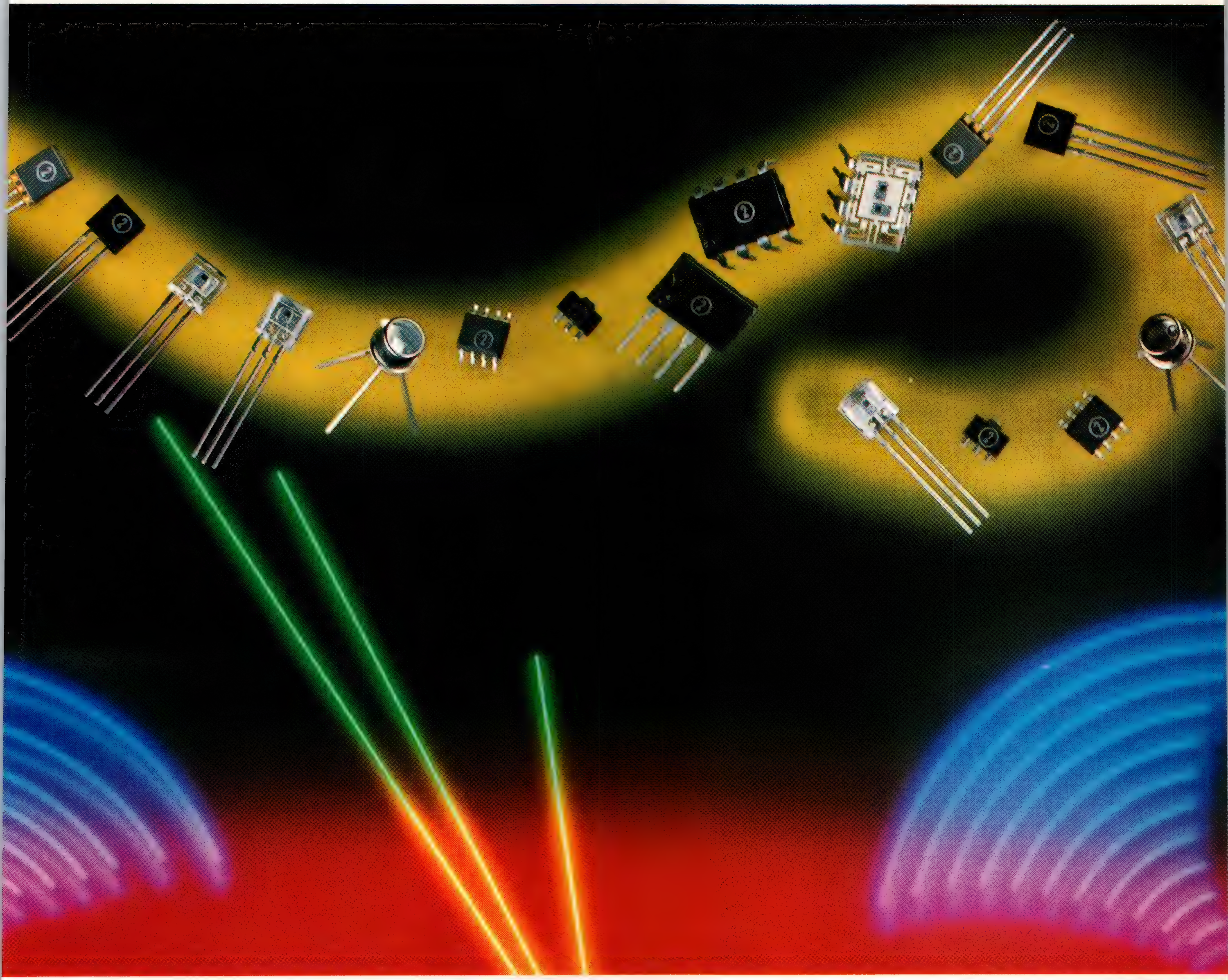
Force is a tradeoff

Although a rotary-to-linear conversion system (such as a lead screw) can generally deliver greater force, its maximum linear velocity is approximately one-tenth that of a comparable linear motor. For many loads, the inertia of the lead screw will exceed the load inertia. When you initiate a high-speed, low-mass move with a lead screw, virtually all the applied torque goes to overcome the lead-screw inertia.

This problem compounds as the length and inertia of the lead screw increase to accommodate longer moves. With a linear motor, the load receives all of the motor's generated force and so no matter how long the move is, the system inertia is confined to the forcer and its load.

If you need precise linear position control, you might want to consider Parker-Hannifin's linear stepper

SENSING YOUR NEEDS.



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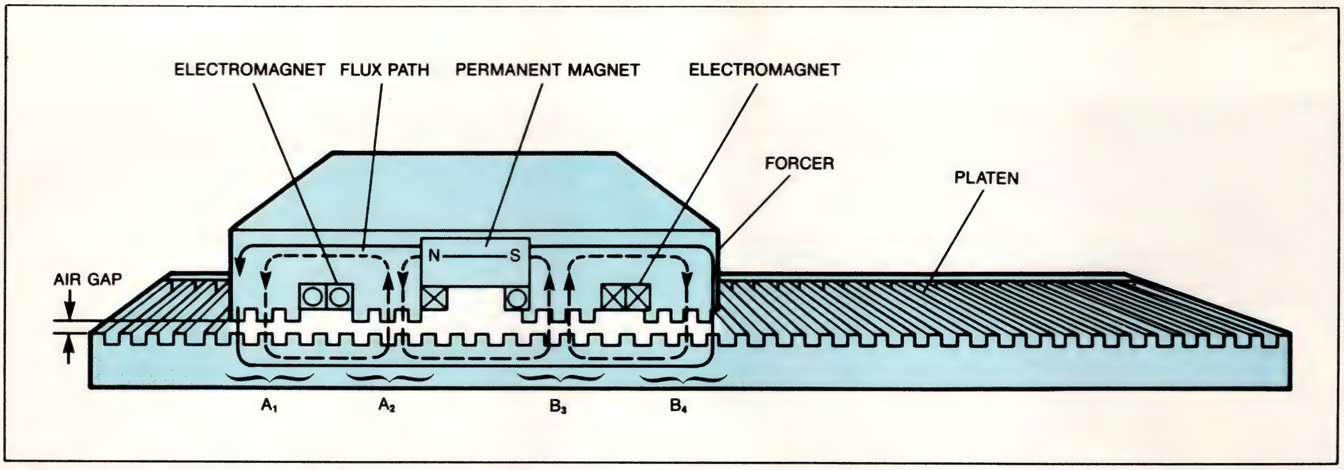

Fig 1—In each linear stepper motor *from Parker-Hannifin, the flux path of a permanent magnet passes through one of two electromagnets, across the air gap between the forcer and platen, along the platen, back across the air gap, and through the other electromagnet to complete the magnetic circuit.*

motors. Their operating principle is similar to that of rotary stepper motors. The forcer, or moving element, consists of two electromagnets that are driven by the two phases of a PWM microstepping drive, as well as a permanent magnet that has an electromagnet aligned at each pole (**Fig 1**). All of the active components—permanent magnet, coils, and bearings—are combined into the forcer so that you can specify the platen, or stationary element, in various lengths to accommodate your application.

The permanent magnet's flux path passes through one of the electromagnets, across the air gap between the forcer and platen, along the platen, back across the air gap, and through the other electromagnet to complete the magnetic circuit. If neither electromagnet is energized, the permanent magnet flux divides equally at the four poles of the electromagnets. When one of the electromagnets switches on, the current in the winding directs all the flux from both magnets through the one pole common to both.

If the energized electromagnet is at the north pole of the permanent magnet, then the flux will pass through its north pole into the platen. No flux will pass through the electromagnet's south pole. The force through the one pole generates a force parallel to the platen, which pulls the forcer along the platen until the teeth of that pole line up with the platen teeth.

Switching current from one magnet to the other moves the forcer one full step along the platen. By changing the direction of the current each time you energize an electromagnet, you change the orientation of the poles. In this manner, the poles align with the platen in a sequence—A_2, B_3, A_1, B_4—and the forcer continues in the initial direction. Reversing the sequence changes the direction of the forcer. A full step for the linear motor is equal to one-fourth the platen-tooth pitch.

Mechanical types reduce roll

Parker-Hannifin's linear stepper motors come with one of two types of bearings: mechanical or air. Each type has advantages. Mechanical bearings reduce system yaw, pitch, and roll. And, they are simple: They don't require plumbing and filtering to provide the necessary air pressure that air bearings require. However, they do add some friction to the linear motor, which reduces settling time.

By comparison, air bearings have no friction in a practical sense, and as such, they do not wear out. And they reduce the width of the air gap, resulting in more force than a comparably sized mechanical bearing. Because the air-bearing-supported forcer floats over the platen, flatness requirements for the overall platen are somewhat less critical. Also, the moving cushion of air helps clean nonabrasive particles from the platen and helps reduce

For more information . . .

For more information on the stepper motors discussed in this article, circle the appropriate numbers on the Information Retrieval Service card or contact the following manufacturers directly.

Airpax Corp
Cheshire Industrial Park
Cheshire, CT 06410
(203) 272-0301
Circle No 701

Parker-Hannifin Corp
Compumotor Div
1179 N McDowell Blvd
Petaluma, CA 94952
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Circle No 702

PMI Motion Technologies
49 Mall Dr
Commack, NY 11725
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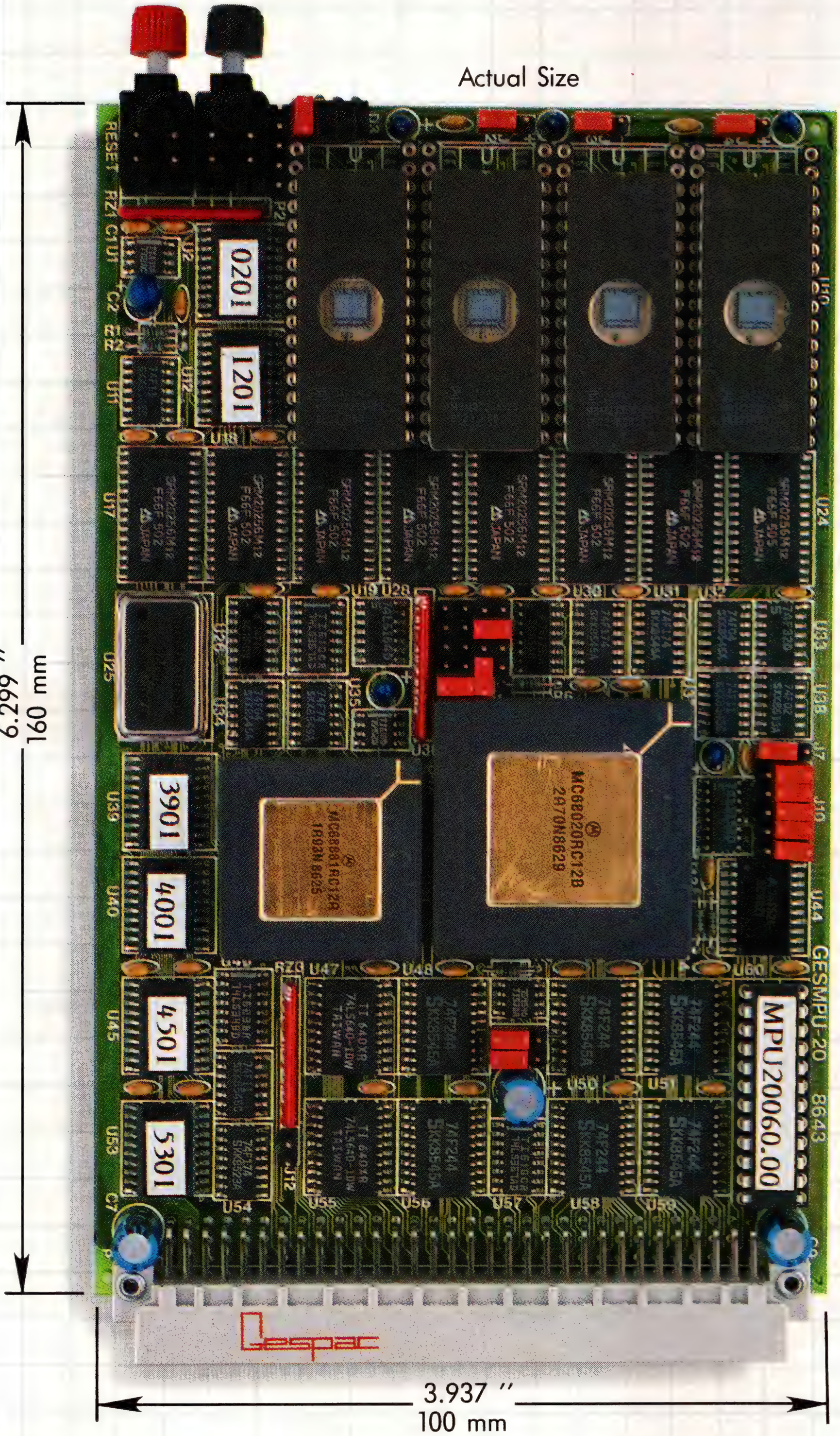

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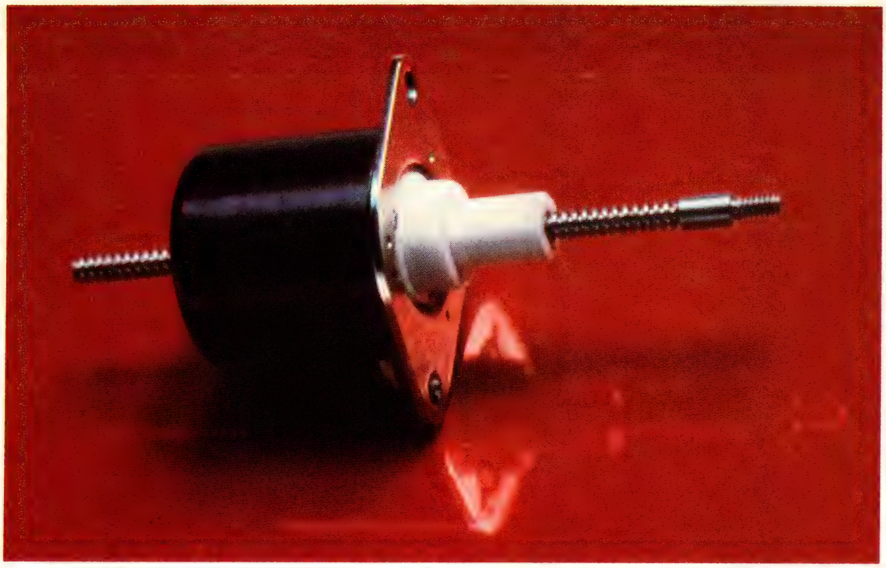

Providing true linear motion when pulsed, *Series 92100 and 92200 bidirectional linear actuators from Airpax are basically stepper motors modified with an internally threaded rotor and fitted with a lead screw shaft. Proper input pulses will move the shaft into or out of the rotor in 0.002 or 0.004 increments.*

the operating temperature.

You have four forcer models to choose from: the L3C, the L5A, the L8C, and the L9A, which generate 3, 5, 8, and 9 lbs of force, respectively. Standard platen lengths are 13 to 120 in., but shorter lengths are available for a cutting charge. Maximum speed is 60 in./sec for the L3C, 40 in./sec for the L5A, 60 in./sec for the L8C, and 40 in./sec for the L8A. For each of these forcers, respective maximum standard platen lengths are 120, 96, 78, and 96 in. with corresponding resolution specs of 7500, 12,500, 5000, and 12,500 steps/in.

The L3C, L5A, and L8C have roller-type bearings, whereas the L9A features air-type bearings. The L3C and the L5A each provide a maximum bearing load of 10 lbs; the L8C is capable of 11 lbs; and the L9A's load is 50 lbs. The price of a forcer includes a drive, the forcer, and a platen. The L3C (with a 15-in. platen) costs $1750; the L5A (13-in. platen) sells for $2995; the L8C (19-in. platen) is priced at $2298; and the L9A (13-in. platen) is $3478.

Airpax's stepper motors provide true linear motion under control of the input pulses. Originally developed for the automotive industry as control elements in car fuel-management systems, these digital linear actuators are now available in commercial versions that find application in computer peripherals (read/write head positioners), and medical instrumentation.

Series 92100 and 92200 bidirectional linear actuators are rotary stepper motors that the company has modified by incorporating an internally threaded rotor and fitting it with a lead screw shaft. When you energize the coils in the proper sequence, the threaded shaft will move out from or back into the rotor in varying linear increments, depending on the particular unit.

For the 92100 Series, this motion measures either 0.002 or 0.004 in./pulse; for the 92200 Series, it equals 0.001, 0.002, or 0.003 in./pulse. The actuator shaft remains in position when you remove power.

The actuator shaft of K92100 models has a maximum travel of 0.5 in., whereas maximum travel for the L92100 versions is 1.875 in. Because the drive digitally controls the shaft, 92100 actuators can reach their full travel point within 0.3 sec for the 0.004-in./step units and 0.6 sec for the 0.002-in./step units. The L92100 Series specs a maximum full travel time of 1.1 sec for its 0.004-in./step units, and 2.2 sec for its 0.002-in./step versions.

Series 92100 units cost $40 to $42 and are available with operating voltages of 5 or 12V. Depending on voltage, maximum force is 15 or 21 oz, and minimum holding force is 7 or 40 oz. Maximum pull-in and pull-out rates are 425 and 650 steps/sec, respectively. The units consume 3.5W, weigh 1.5 oz, and operate over −40 to +85°C.

The Series 92200 ranges in price from $65 to $85 and offers maximum linear force ratings spanning 32 to 75 oz. For K-prefix units, the actuator shaft has a maximum travel of 0.875 in.; for L-prefix units, it's 2.5 in. Digital control allows full extension or retraction of K unit shafts within 0.58 sec (0.003-in./step unit), 0.875 sec (0.002-in./step unit), and 1.75 sec (0.001-in./step unit). L Series actuators will fully extend or retract within 1.7 sec (0.003-in./step unit), 2.5 sec (0.002-in./step unit), or 5 sec (0.001-in./step unit).

The series' minimum holding force specifications range from 8 to 40 oz. Respective maximum pull-in and pull-out rates are 500 and 700 steps/sec. The motors consume 5W and operate from −40 to +85°C.

EDN

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Fluorinert™ **Liquids**–products that power Fluoronics Resource

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Our FC™ numbers — FC-40, FC-70, FC-77, etc. — are used to identify Fluorinert Liquids that offer certain physical characteristics to meet specific application needs. These FC numbers are solely 3M designations for various fluorochemical products.

Fluorinert Liquids are being used cost-effectively in cooling, high reliability testing and vapor phase soldering operations. When you are interested in applying these versatile liquids in your own production, 3M can provide an abundance of technical information and support.

Technical assistance: the main benefit of Fluoronics Resources

3M offers prompt assistance to help you solve many production and testing problems. We provide comprehensive technical recommendations for specific fluids. We consult with you on the proper application equipment and help you evaluate production methods and results. Our service bulletins bring you up to date on the most recent advances in vapor phase soldering and high reliability testing. Ask us about 3M's audiovisual materials and on-site application training seminars.

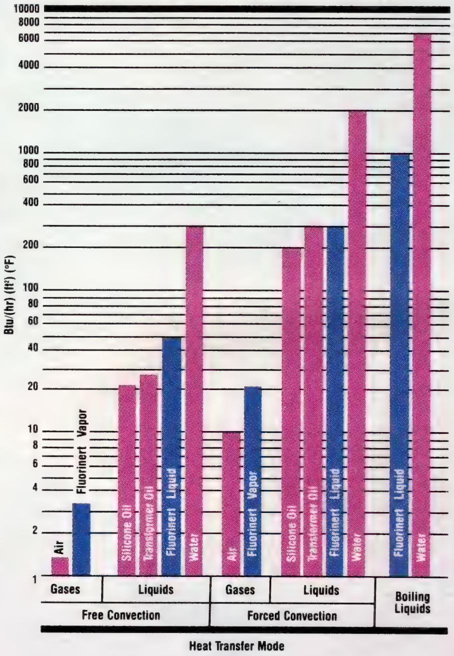
Discover Fluorinert™ Liquids' heat transfer capability

What are your needs? A precise degree of temperature control? Fast, uniform heat transfer? High dielectric strength? Fluorinert Liquids offer the broad range of physical characteristics required in most applications.

Fluorinert Liquids are an effective direct contact heat transfer medium whether used in a liquid or vapor state. Their unique properties enable you to use them in contact with sensitive components and substrates.

Major differences between the various products in the Fluorinert Liquids family can be seen in their boiling points. These can range from 56°C to 253°C. Should you need products with intermediate boiling temperatures, the 3M staff will work with you to fashion a product especially for your needs. It's an example of how 3M's Fluoronics Resources provide you with "customized" service to solve special problems.

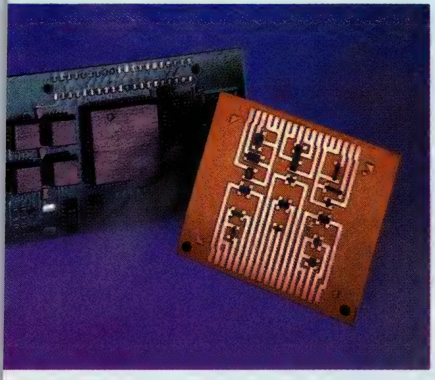
COMPARATIVE HEAT TRANSFER COEFFICIENTS



Fluorinert™ Liquids achieve accurate high reliability testing

It's a small world you work in. Where time ticks in gigaseconds and dimension is measured in Angstrom units. And as circuitry becomes more complex, a greater demand is placed on testing capability — not only in speed, but in higher reliability and accuracy.

Fluorinert Liquids meet those requirements by providing a controlled temperature environment and a high degree of electrical protection. They offer maximum compatibility between



the heat transfer medium and the device under test. Fluorinert Liquids reduce testing costs by reducing testing time substantially. They do this by rapidly reaching test temperature and providing precise and uniform temperature control. You'll minimize the number of faulty units by detecting defects before they become rejects.

These liquids provide cost-effective tests such as gross leak, thermal shock, liquid burn-in, ceramic crack detection, electrical environmental, temperature calibration and failure analysis/short detection.

Fluorinert Liquids are specified in the MIL-STD's for thermal shock and gross leak testing.

THERMAL SHOCK TEST CONDITIONS

Military Standard 883-1011			Military Approved Fluorinert Liquids	
Test Condition	**Hot Test Step 1**	**Cold Test Step 2**	**Hot Test Step 1**	**Cold Test Step 2**
A	100°C	– 0°C	Water , FC-40	Water , FC-40, FC-77
B	125°C	– 55°C	FC-40, FC-70, FC-5311	FC-77
C	150°C	– 65°C	FC-40, FC-70, FC-5311	FC-77
D	200°C	– 65°C	FC-70, FC-5311	FC-77
E	150°C	– 195°C	FC-40, FC-70, FC-5311	Liq. N_2
F	200°C	– 195°C	FC-70, FC-5311	Liq. N_2

GROSS LEAK TEST CONDITIONS

Military Standards	Military Approved Fluorinert Liquids		
	Indicator Fluids	**Detector Fluids**	**Absorption Fluids**
MIL-STD 883-1014	FC-40, FC-43	FC-72, FC-84	Do not apply
MIL-STD 750-1071	FC-40, FC-43	FC-72, FC-84	FC-43, FC-75, FC-77
MIL-STD 202-112	FC-40, FC-43	FC-72, FC-84	Do not apply

Discover higher yields in vapor phase soldering

Fluorinert Liquids have been the industry's fluid of choice since the vapor phase reflow soldering (VPS) process was introduced in 1975. There are a number of good reasons for this universal acceptance. VPS with Fluorinert Liquids produces highly reliable solder joints. The system reduces reject rates, increases production, and lowers production costs. With Fluorinert Liquids, you can be assured that your products will never be exposed to a temperature higher than the selected liquid's boiling point. (See above)

You'll avoid those problems usually associated with other systems — shadowing, uneven heating, and overheating. The liquids are non-flammable. Their low surface tension helps them evaporate quickly from the work pieces without leaving a residue.

VPS with Fluorinert Liquids is especially suited for boards with high mass or complex geometries. The liquid vapors completely surround the assembly and penetrate remote recesses to heat all surfaces evenly. The vapors are 15 to 20 times heavier than air so they can be contained easily within the work area. The system offers an oxygen-free, non-corrosive environment to minimize rejects from oxidation contamination.

Some typical applications using Fluorinert Liquids in VPS include surface mounted leaded or leadless components, through-hole leads and wire-wrap pins, lead frame attachment, reflow of electroplated solder or tin and miscellaneous metal joining.

VPS SELECTION GUIDE

Fluorinert Liquid	Boiling Point	Typical Solders
FC-43	174°C/345°F	70 Sn/18 Pb/12 In 100 In 58 Sn/42 In 58 Bi/42 Sn
FC-70, FC-5311 FC-5312	215°C/419°F	63 Sn/37 Pb 60 Sn/40 Pb 62 Sn/36 Pb/2 Ag
FC-71	253°C/487°F	100 Sn 95 Sn/5 Ag 60 Pb/40 Sn

Discover the unique cooling benefits of Fluorinert™ Liquids

As the package size decreases, your need for more efficient heat dissipation increases in proportion. 3M Fluorinert Liquids are very efficient as a direct contact heat transfer medium, with the added advantage of having the high dielectric characteristics needed to meet stringent demands of the diversified electronics industry. We offer 11 liquids with boiling points that range from 56°C to 253°C.

These stable liquids allow you to maximize power density and miniaturize your package. Yet they reduce failure rates and increase reliability.

Fluorinert Liquids are used in such demanding applications as:

- Radar transmitters • Power supplies
- High voltage transformers • Lasers
- Radar klystrons • Computer modules
- Computer memories • Fuel cells

Typical properties of Fluorinert Liquids used in cooling are:

Fluorinert Liquid FC-77 (English Units)	Liquid		Vapor
	Room Temp. (77°F)	**Boiling Point (207°F)**	**Boiling Point 207°F @/ATM**
Density lb./ft^3	111	100	0.85
Thermal Conductivity Btu/(hr) (ft^2) (°F/ft)	0.037	0.033	0.008
Specific Heat Btu/(lb.) (°F)	0.25	0.28	0.23
Viscosity c.p.	1.42	0.46	0.02
Coefficient of Thermal Expansion ft^3/(ft^3) (°F)	0.0008	0.0009	0.0015

Discover heating/curing with Fluorinert™ Liquids

Because they maintain their vapor temperature with absolute precision, Fluorinert Liquids can be used in many heating and/or curing operations. They serve as heat transfer media in solder mask and polymer thick film applications and for polymer processing. The non-corrosive vapors will not support oxidation. Ideal where solvent flash-off is a problem.

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3M

Discover Fluoronics Resources

3M presents a unique short course in the use of Fluorinert™ Liquids for the electronics industry.

3M is now offering a series of "Applied Fluoronics" tapes demonstrating how Fluorinert Liquids are used in a number of applications. See first hand how these remarkable products can improve overall electronic production.

Three cassettes are available:
1. "Applied Fluoronics: High Reliability Testing"
2. "Applied Fluoronics: Vapor Phase Soldering"
3. "Applied Fluoronics: Direct Contact Cooling"

These informative VHS format tapes are available to qualified personnel in the electronics industry. Specify which cassette(s) you would like to view.

Write on your company letterhead, describing your general interest. Mail to: Fluoronics Resources, Industrial Chemical Products Division/3M, Building 223-6SE-04, 3M Center, St. Paul, MN 55144-1000.

For technical information or assistance on High Reliability Testing and Cooling, call 612/733-6282; for Vapor Condensation Heating assistance, call 612/733-7424.

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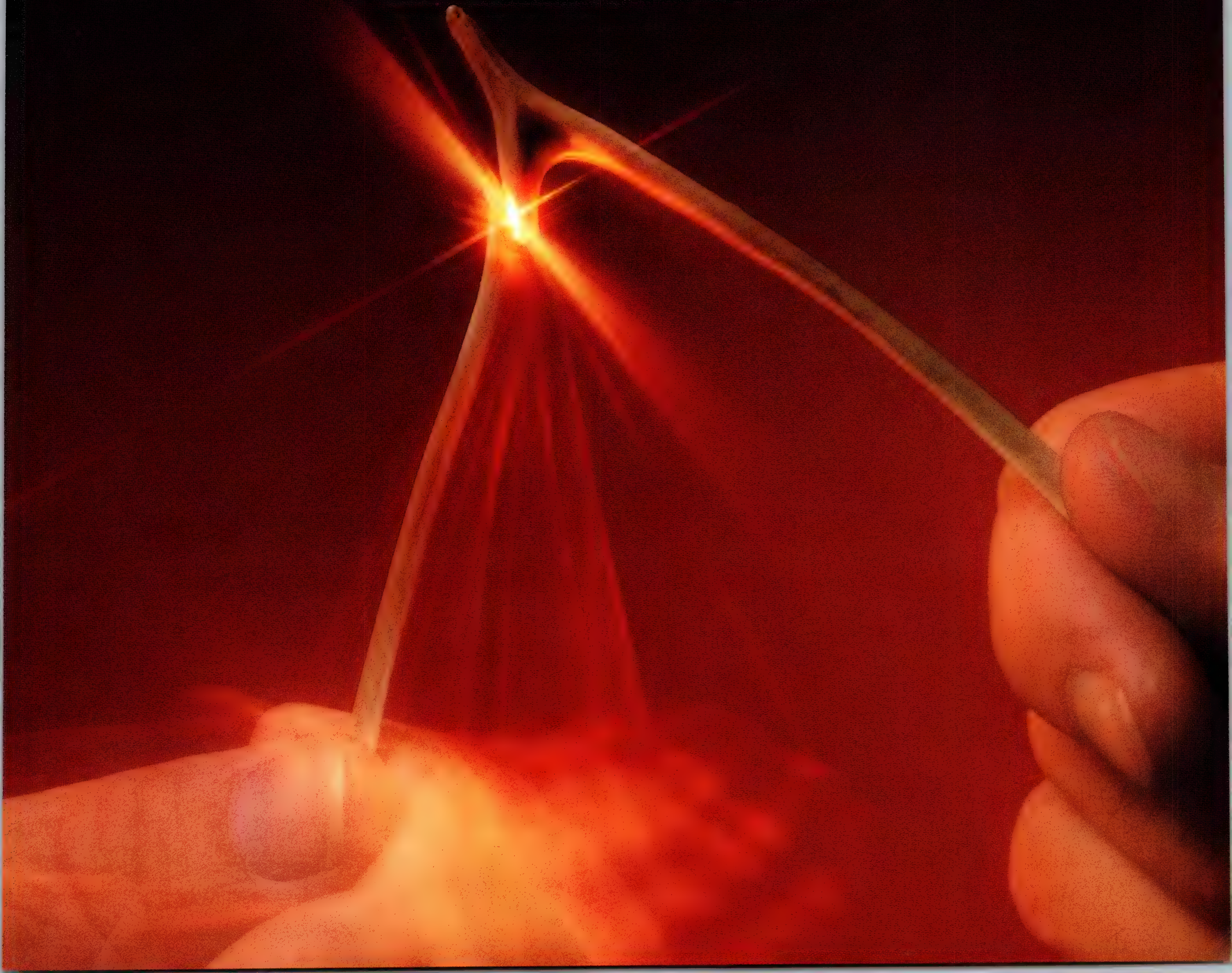

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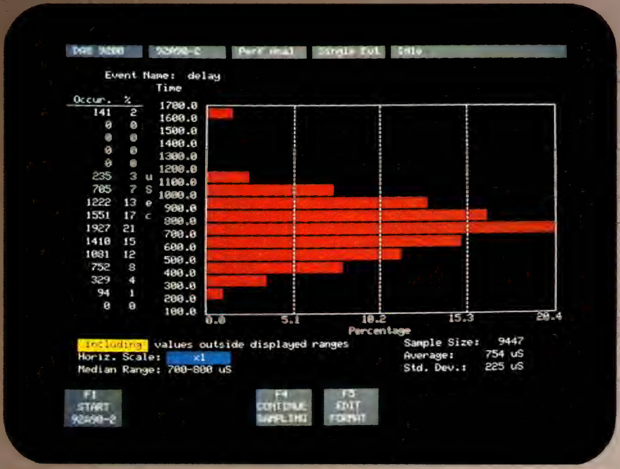
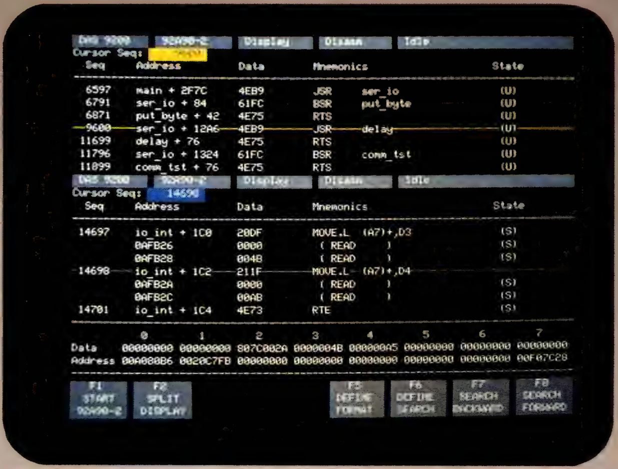


```
      Event Name:  delay
                    Time
 Occur.   %        1700.0
   141    2        1600.0
     0    0        1500.0
     0    0        1400.0
     0    0        1300.0
     0    0        1200.0
   235    3  u     1100.0
   705    7  s     1000.0
  1222   13  e      900.0
  1551   17  c      800.0
  1927   21         700.0
  1410   15         600.0
  1081   12         500.0
   752    8         400.0
   329    4         300.0
    94    1         200.0
     0    0         100.0

 including  values outside displayed ranges      Sample Size:    9447
 Horiz. Scale:    x1                             Average:      754 uS
 Median Range: 700-800 uS                        Std. Dev.:    225 uS
```

Software Performance Analysis, like this distribution of a subroutine's execution times, helps you easily understand the activity of your code.



```
Cursor Seq:
 Seq     Address          Data      Mnemonics                    State
------------------------------------------------------------------------
  6597   main + 2F7C      4EB9      JSR     ser_io               (U)
  6791   ser_io + 84      61FC      BSR     put_byte             (U)
  6871   put_byte + 42    4E75      RTS                          (U)
  9600   ser_io + 12A6    4EB9      JSR     delay                (U)
 11699   delay + 76       4E75      RTS                          (U)
 11796   ser_io + 1324    61FC      BSR     comm_tst             (U)
 11899   comm_tst + 76    4E75      RTS                          (U)
Cursor Seq:   14698
 Seq     Address          Data      Mnemonics                    State
------------------------------------------------------------------------
 14697   io_int + 1C0     20DF      MOVE.L  (A7)+,D3             (S)
         0AFB26           0000       ( READ    )                 (S)
         0AFB28           004B       ( READ    )                 (S)
 14698   io_int + 1C2     211F      MOVE.L  (A7)+,D4
         0AFB2A           0000       ( READ    )                 (S)
         0AFB2C           00AB       ( READ    )                 (S)
 14701   io_int + 1C4     4E73      RTE                          (S)
------------------------------------------------------------------------
            0        1        2        3        4        5        6        7
Data     00000000 00000000 807C002A 0000004B 000000A5 00000000 00000000 00000000
Address  00A000B6 0020C7FB 00000000 00000000 00000000 00000000 00000000 00F07C28
```

Step backwards through acquired data, including subroutines, stack and register models, using time-correlated split-screen displays to pinpoint problems.

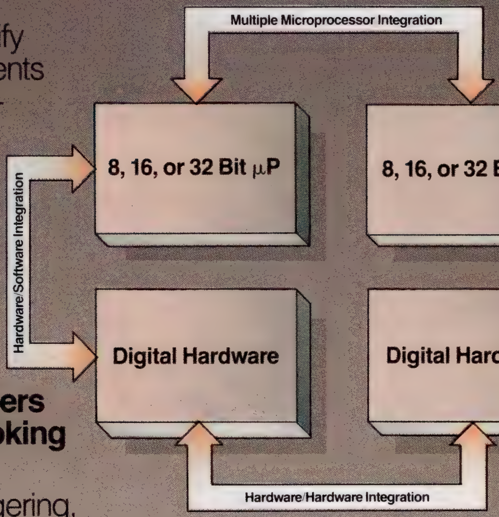
In every dimension—speed, channel width, memory depth, trigger capability, modularity and ease of use—the DAS9200 dwarfs what's been possible before.

The DAS9200 features a tightly coupled, high-speed architecture in which multiple card modules can act as a single unit. Large color-coded displays, pop-up menus, performance analysis graphs, multi-tasking and more combine to uncomplicate logic analysis.

1 Apply state-driven triggering at 200 MHz with up to 384 channels of sync and async data acquisition.

You can assurance-test high-speed logic at full speed, using 4-level state tracking and high speed counter/timers integrated into the 92A16 timing board.

You can monitor and verify all the timing measurements in a circuit, including setup and hold time, minimum pulse width, and precharge time, and quickly select common-test routines from the Trigger Library.


Multiple Microprocessor Integration
8, 16, or 32 Bit μP
8, 16, or 32 Bit μP
Hardware/Software Integration
Hardware/Software Integration
Digital Hardware
Digital Hardware
Hardware/Hardware Integration

2 Register deduction and stack simulation let developers debug software by looking backwards in time.

Use the complex triggering, data qualification and 32K per channel memory of the 92A60/92A90 acquisition modules to monitor software activity in real time.

Continually updated register and stack displays let you quickly identify problems like stack overflow or incorrectly restored pointers—without breakpoints and manual notation.

3 Split-screen time-correlated displays help you monitor and correlate up to six microprocessors at once.

Take the same system modules used in debugging the hardware and software and reconfigure them *from the keyboard* for integrating partitioned designs or multiple microprocessors.

Use the dual timebases and real-time handshaking between modules to set up split-screen displays of disassembly with timing or state table data. Lock the two cursors so that both screens scroll in precise time alignment.

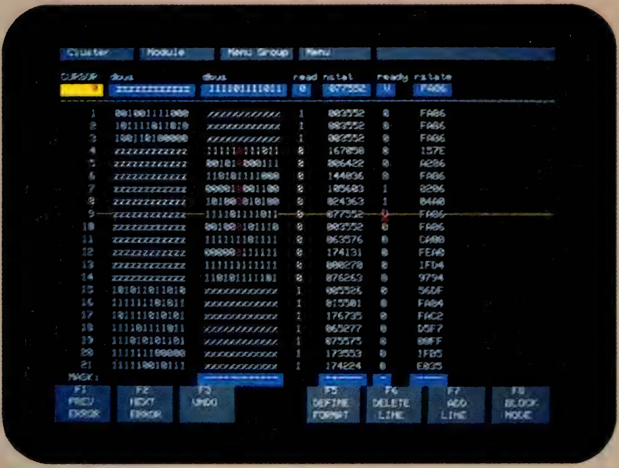
4 Acquire up to 160 channels at a full 2 GHz for unprecedented 500 ps sampling.

The 9200 offers the first acquisition unit to split the nanosecond: the 92HS8. With its 500 ps sample interval and 1.5 ns glitch detection, you can identify previously undetectable race conditions, spurious clocks and setup/hold violations in any logic family.

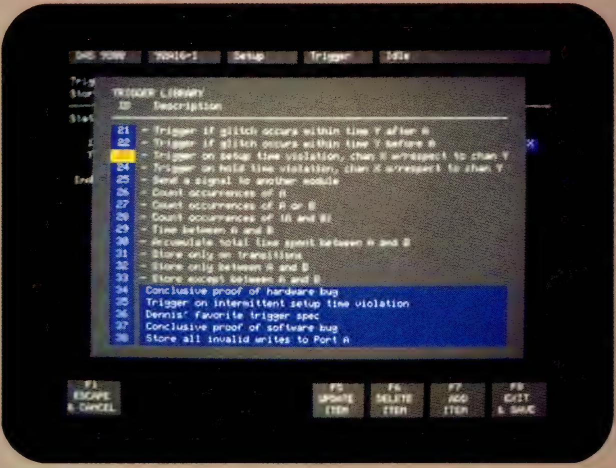
The 92HS8 is complemented by the world's most advanced probing system, featuring an input capacitance of less than 1 pf.

Available in desktop and rack-mount versions, the DAS9200 mainframe can be augmented with up to three expansion mainframes for a total of 28 card slots.

BENCHTOP ASIC OR PCB TESTS? YOUR WISH IS OUR COMMAND!



Results of the ASIC prototyping system can be displayed in timing or state format, with differences from expected results clearly highlighted.



```
TRIGGER LIBRARY
 ID   Description
 21 - Trigger if glitch occurs within time Y after A
 22 - Trigger if glitch occurs within time Y before A
    - Trigger on setup time violation, chan X w/respect to chan Y
 24 - Trigger on hold time violation, chan X w/respect to chan Y
 25 - Send a signal to another module
 26 - Count occurrences of A
 27 - Count occurrences of A or B
 28 - Count occurrences of (A and B)
 29 - Time between A and B
 30 - Accumulate total time spent between A and B
 31 - Store only on transitions
 32 - Store only between A and B
 33 - Store except between A and B
 34   Conclusive proof of hardware bug
 35   Trigger on intermittent setup time violation
 36   Dennis' favorite trigger spec
 37   Conclusive proof of software bug
 38   Store all invalid writes to Port A
```

With the Trigger Library, you don't need to know the microprocessor microcode or the bits and bytes of trigger setup to tackle once-difficult problems.

5 The DAS9200 is available as a low-cost turnkey ASIC device verification system.

Featuring 50 MHz pattern generation, 8K bit vector depth, 1 ns edge placement and 0.5 V/ns slew rates, it is an accessible, easy-to-use alternative to centralized systems.

You can link to popular logic simulators, download test vectors, call up split-screen displays and analysis graphs, utilize multiple sets of patterns and parameter sweeps, and display results in timing or state format, with anomalies clearly highlighted.

6 The DAS9200 frees circuit board functional testing from costly and complicated central test systems.

Configure up to 1008 channels of stimulus at 50 MHz with 8K bits/channel of pattern memory. Up to 540 channels of acquisition at 20 MHz with 32K bits/channel memory. Or many other combinations.

Time-correlated module interactions let you use data acquired by one acquisition or stimulus module to change the activity of another for more realistic conditional testing… all for under $700 per I/O pin!

Compare your wish list against the complete list of DAS9200 capabilities. Contact your Tek sales engineer for the full story and the hands-on proof. Or call toll-free for more information.

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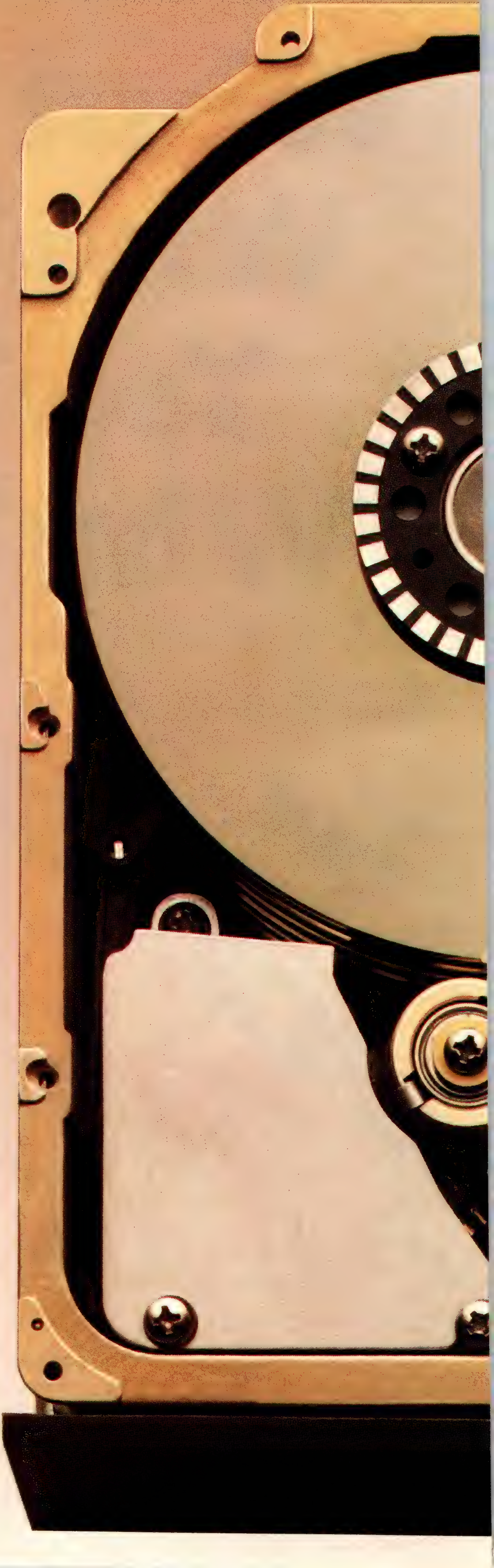

The reliable side.

At Quantum, we put at least half our thinking into making disk drives reliable.

Our Q200 Series™ of 5¼″ intelligent disk drives is the perfect example of achieving near-perfection.

The specified mean time between failure for our Q200 Series is 25,000 operating hours. Our customers' incoming acceptance rate for all our products is over 99%. And the many ship-to-stock programs with our customers underscore a confidence level that's even higher.

The extraordinary reliability of our Q200 Series drives is the result of the out-of-the-ordinary things we do to make them that way.

Because we were the first to make intelligent 5¼″ disk drives, we have more field-proven experience in making them to last. And because we designed both the SCSI controller electronics and the drive, they truly perform as if they were made for each other.

The Q200 Series drives are available in 53MB, 80MB and 160MB (formatted) capacity models. And our new custom-designed, semi-automatic manufacturing line in Milpitas has the capacity to make these high quality drives at the rate of one every 30 seconds. So availability is one more thing you can rely on — from Quantum.

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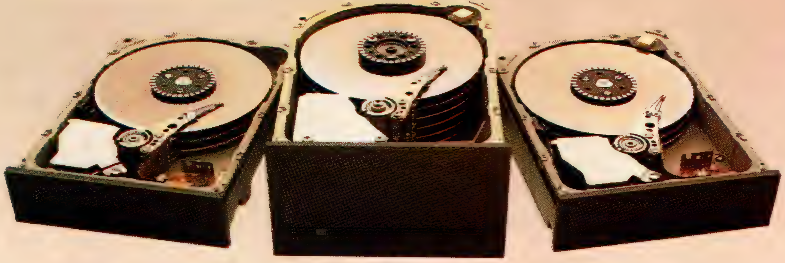

Q250 (53MB) **Q160 (160MB)** **Q280 (80MB)**

Quantum

First In Intelligent Disk Drives

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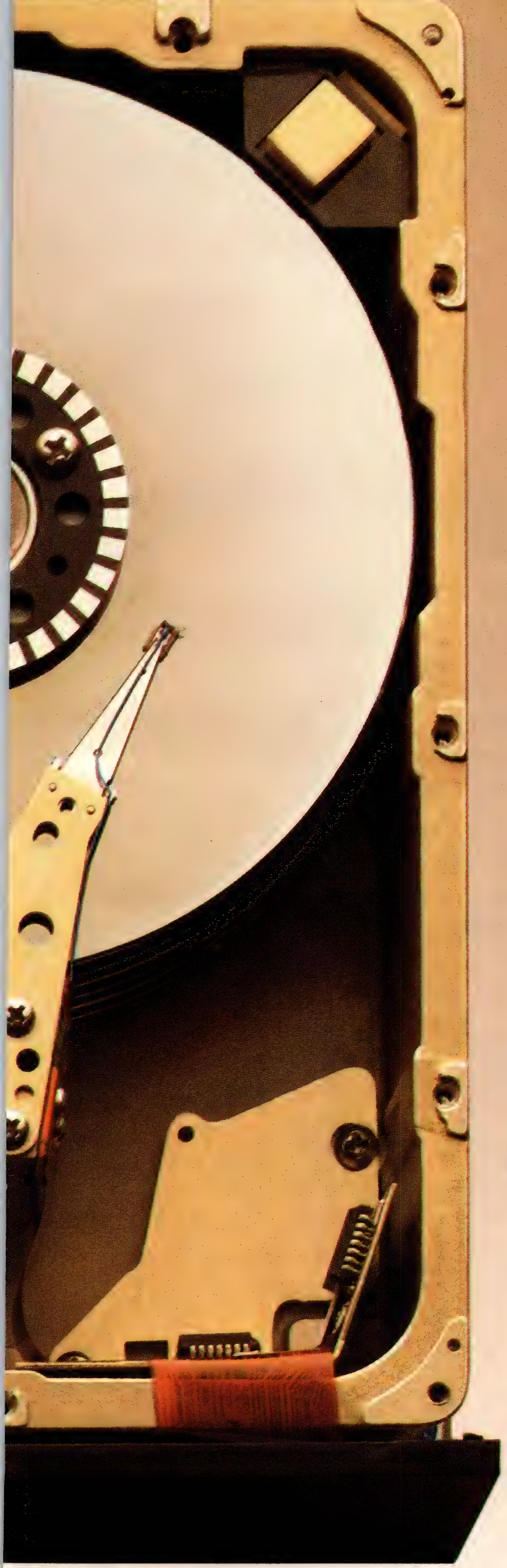
e two sides, too.



The innovative side.

At Quantum, we put at least half our thinking into making disk drives innovative.

Our Q200 Series™ of intelligent disk drives is the best example of doing things ever better.

The half-height 53MB and 80MB (formatted) capacity models were the very first intelligent drives introduced — a major advancement in disk drive architecture, integrating a custom SCSI controller into the drive itself.

Soon thereafter, we introduced our full-height 160MB (formatted) capacity intelligent disk drive. This new model in the Q200 family incorporates yet another major advance — DisCache,™ a look-ahead, high-speed memory to significantly increase data throughput, with programmable options for individual application needs.

All three models in the Q200 Series use the same heads, the same media, and the same integrated controller design. They also use the same SCSI interface and support the same software commands, utilizing the industry standard common command set. That's why we can guarantee compatibility among the family, making it easier than ever to upgrade and enhance your systems — now and with future products. So if you're looking for future innovations, Quantum is where to look first.

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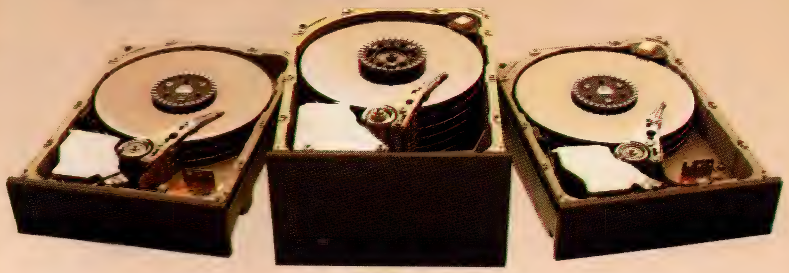

Q250 (53MB) Q160 (160MB) Q280 (80MB)

Quantum

First In Intelligent Disk Drives

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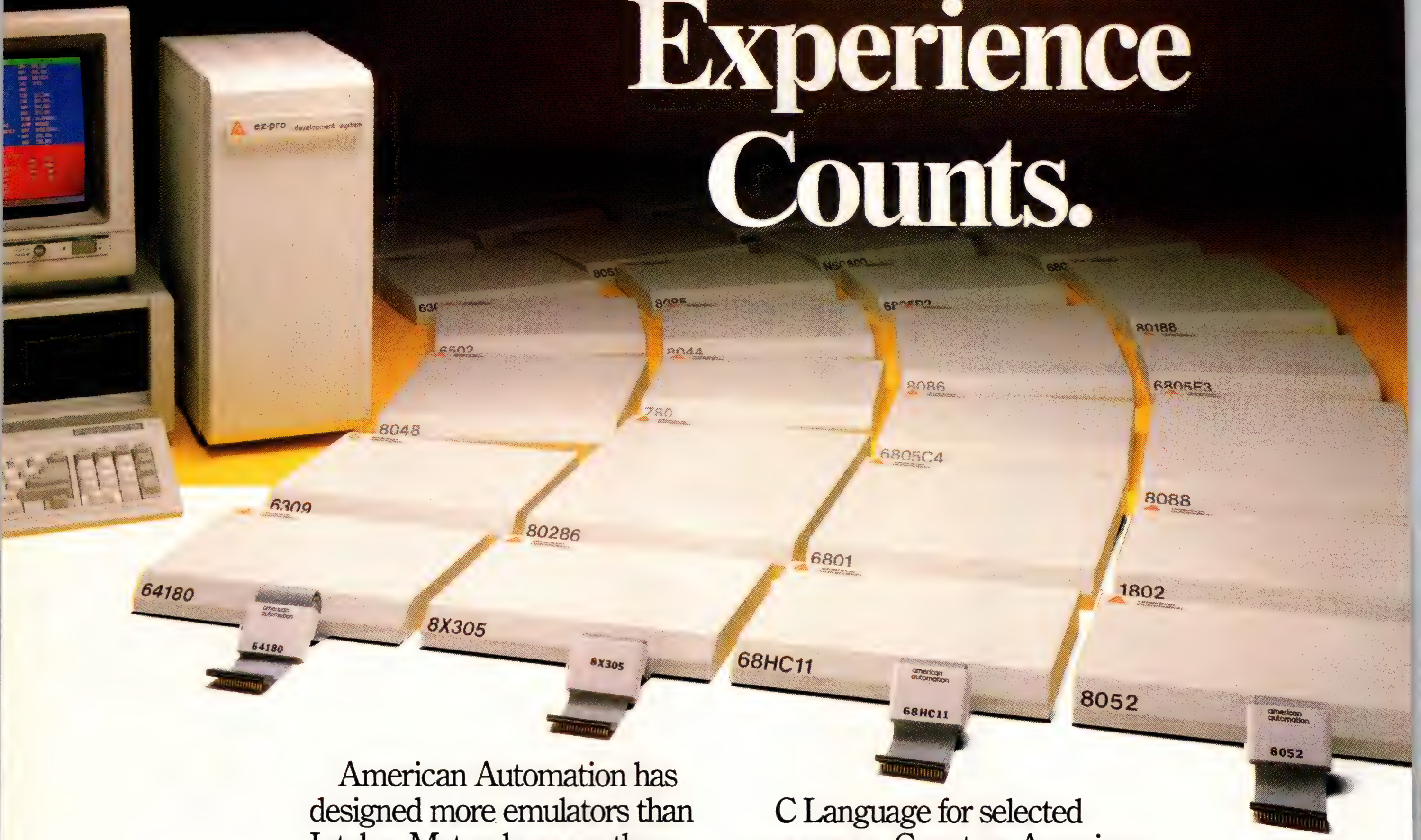
CIRCLE NO 86

Experience Counts.



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Harris: 80C86 80C88	**NEC:** V20 V30	**RCA:** 1802 1805 1806 CDP6805C4 CDP6805D2 CDP6805E3	**Signetics:** 8X300 8X305
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CIRCLE NO 87

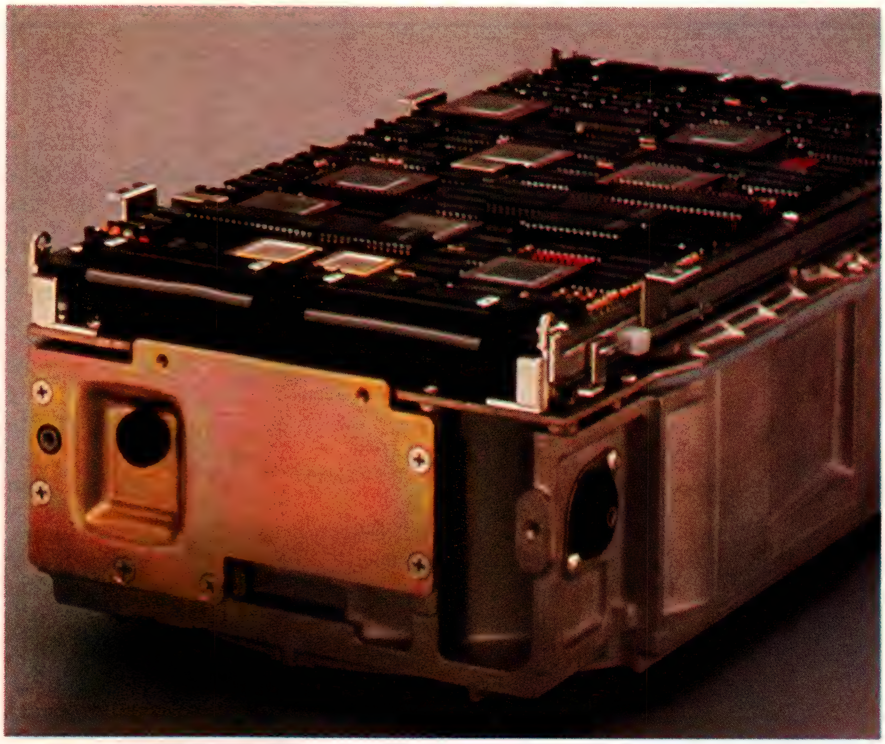
Intelligent Peripheral Interface standard permits data-transfer rates of 10M bytes/sec

Maury Wright, *Regional Editor*

High-end peripheral products, especially Winchester disk drives, have outgrown such I/O interface standards as the Storage Module Device (SMD) and Enhanced Small Device Interface (ESDI) standards. Both system manufacturers and users are now beginning to demand improved I/O performance from these peripherals.

The Intelligent Peripheral Interface (IPI) specifies a high-performance solution to this problem at the device and I/O-bus levels. The IPI standard for both levels permits the interface to operate at 5 MHz and to support a 10M-byte/sec transfer rate.

A number of major vendors of high-performance Winchester disk drives have embraced the IPI standard for their high-speed I/O peripherals. Hard-disk drives implementing the device-level interface (IPI-2) are already available. Furthermore, interface- and peripheral-controller chips dedicated to IPI applications will soon be available in production quantities, and you can expect controller houses to ship IPI board products this year.



***Custom IPI-2 chips**, developed by Fujitsu, control the Model M2333P 8-in. Winchester disk drive, which stores 337M bytes and operates at 2.5M bytes/sec.*

IPI defines a 16-bit data path

Because it defines a 16-bit data path, the IPI standard will facilitate the development of higher-performance computers. IPI-2 is the first standard implementation of a device-level interface that transfers data in a parallel fashion.

The IPI-2 device-level interface and the IPI-3 I/O-bus interface are physically identical. However, IPI-2 uses device-specific commands and is timing-critical; IPI-3 uses high-level, device-generic commands and is timing-independent (see **box**, "IPI: a layered interface").

Depending on the type of system you're developing, you'll be able to use either IPI-2 or IPI-3 products, or both. The IPI-3 standard defines a high-performance and flexible I/O-bus architecture that suits I/O-subsystem applications for supermicro-, mini-, and mainframe-computer applications. IPI-3 allows a system to support many different types of peripherals at the same time. At present, the CPU performance of such computers outstrips the capability of non-IPI standard I/O-interconnection schemes. Within an IPI-3 subsystem, manufacturers can use IPI-3/IPI-2 controller boards and IPI-2 devices.

IPI-2 peripherals will suit less complex systems, such as graphics systems and CAE workstations, which require high-performance I/O between the computer and primary-storage devices such as disk drives but which don't need to support many different types of peripherals at the same time. A dedicated IPI-2 controller for the VME Bus, Multibus I/II, or another bus will suit these applications.

The IPI specification was developed primarily by a group of Winchester disk-drive vendors who are members of ANSI committee X3T9.3, which controls the specification. Some disk-drive-controller and IC manufacturers have also worked on the specification. During the development of the IPI standard, some of the disk-drive manufacturers banded together to promote the development of IPI ICs for use on IPI disk drives. These manufacturers contracted with Simulex Corp to develop a chip set that would simplify the implementation of IPI-2 in a disk drive. (Simulex specializes in designing custom ICs for the data-storage industry.)

The development of this chip set was originally funded by Ampex Corp (El Segundo, CA), Century Data Systems, Fujitsu, Control Data Corp, NEC, Pertec Peripherals Corp (Chatsworth, CA), Priam Corp (Santa Clara, CA), and Storage Technology Corp (Louisville, CO). Priam dropped out early in the program, and Hitachi and IBM joined later.

Simulex still invites drive manufacturers to join the group for $100,000, the price that each of the

IPI: a layered interface

Manufacturers of peripherals, controller boards, and controller chips have embraced the Intelligent Peripheral Interface (IPI) standard for high-performance peripherals, especially for hard-disk drives. The IPI standard specifies a layered interface that's specifically optimized for high I/O performance at the device and I/O-bus levels. The standard supports a 10M-byte/sec transfer rate, minimal command latency at the device level, device independence at the I/O-bus level, and a common physical and electrical interface scheme.

The IPI standard employs a master/slave approach to interface design. In its simplest form, the master/slave configuration employs a single host, or master, that's connected to one or more peripherals, or slaves. The IPI specification defines a single master, and a maximum of eight slaves. The standard serves many types of peripherals, including disk drives, tape drives, and communication facilities. ANSI committee X3T9.3 presides over the IPI spec as well as over other I/O standards, such as the Enhanced Small Device Interface (ESDI) standard.

IPI has four layers

The IPI specification consists of four levels or layers. IPI level 0 (IPI-0) defines the mechanical aspects of the interface standard, such as the type of wire, shielding, and connectors. For example, the document specifies a choice of ribbon, twisted-pair, or coax cables. You make your choice based on the total distance the cable must cover between the master and all slaves. Ribbon cable is usually sufficient inside a box, but twisted-pair cable serves a 70m maximum cable length, and coaxial cable stretches the maximum to 200m.

The connection scheme specified by IPI-0 implements a 16-bit (2-byte) parallel data bus. IPI-1 defines the bus protocol used for communication over the 16-bit bus. The protocol definition includes the state machine needed to implement the protocol, as well as the procedure for bus operations, such as device selection, deselection, and polling.

IPI-1 inherently includes IPI-0, and the two are typically referred to as the physical interface. The physical interface allows for data transfer across the bus at 10M bytes/sec. The bus actually operates at 5 MHz, so it provides a 5M-bps transfer speed on each of the 16 data lines. The ANSI committee is already considering doubling the data-transfer rate that IPI specifies. In addition, the committee's future plans call for the expansion of the parallel data path to a maximum of 128 bits in groups of 16. Such plans ensure the longevity of the IPI standard.

IPI-2 defines 16-bit device interface

IPI-2 defines a device-level interface, as do the ESDI, SMD, and QIC-36 standards. Unlike these other standard device-level interfaces, which specify a serial data path, the IPI-2 specifies a 16-bit parallel data path. The SMD interface, for example, operates at 24 MHz, but its serial data path limits transmission to 3M bytes/sec.

At present, IPI-2 includes a specification for interfacing only rotating media (magentic- and optical-disk drives), but the committee is working on the specification for a tape interface. The IPI-2 spec inherently includes IPI-1, and therefore IPI-0.

The IPI-2 interface possesses the characteristics of both a tagged and a programmed interface. A peripheral on a tagged interface, such as SMD, bases its operation on tags, or predefined signals at the hardware interface. The peripheral hardware responds immediately to the tag. A programmed interface, such as ESDI, accepts commands via the serial data path and interprets the commands before taking action.

Programmed interfaces can include more device-level intelligence than can their tagged counterparts. Tagged interfaces, however, typically offer better performance. The IPI-2 standard specifies that peripherals react to commands inherent in the bus protocol, which are essentially tags. However, like programmed interfaces, IPI-2 peripherals also include intelligence for use in transferring data and other vendors paid. For the $100,000, the drive vendors receive full details of the chip set; they're permitted to build the devices themselves or buy them from a semicustom vendor. Once the license fee is paid, the drive vendor pays only the cost of the silicon for parts. Simulex shipped working chips to the group of manufacturers in the second half of 1986. At present, it's not clear whether the chip set will be offered commercially.

The chip set includes the SX1601 interface-protocol circuit and the SX1602 SERDES (serializer/deserializer) formatter circuit. A single SX1602 can arbitrate between two SX1601s for dual-ported drive applications. In addition to the two chips, IPI-2 drives basically re-

---

status via the parallel data bus.

Like IPI-2, the IPI-3 standard inherently includes IPI-1. IPI-3, however, serves the I/O-bus function, as does the SCSI (Small Computer System Interface) standard. Like the SCSI standard, IPI-3 provides a high-level architecture for system I/O, but instead of using SCSI's peer-to-peer scheme, IPI-3 maintains the master/slave architecture. The IPI-3 standard includes system-level commands and command packets that serve subsystems, including disk-storage, tape-storage, and communications (network) subsystems. The IPI architecture provides device independence and relies on the slave controller to interpret the high-level commands.

IPI-2 and IPI-3 can be used independently of each other or can fit together in a variety of complementary applications. In one such complementary application, a computer links to an IPI-3 I/O bus via a host adapter. The IPI-3 bus allows the host to connect to a variety of peripherals. Any peripheral can include an IPI-3/IPI-2 controller board and an IPI-2 device-level interface (this configuration is a bridged controller). A bridged controller lets you use an IPI-3/IPI-2 controller board to connect an IPI-3 host to an IPI-2 peripheral in the same way that you'd use a SCSI/ESDI controller board to connect a computer containing a SCSI host adapter to an ESDI drive.

An IPI-3/IPI-2 controller also suits bridged-controller applications, in which an I/O bus is separated from a device-level interface by a controller board. In IPI bridged-controller applications, the IPI-3 side of the controller acts as a slave to the host adapter. On the IPI-2 side, the controller acts as master to a peripheral device, such as a Winchester disk. The separate interface buses between the host adapter/controller and the controller/device are physically identical.

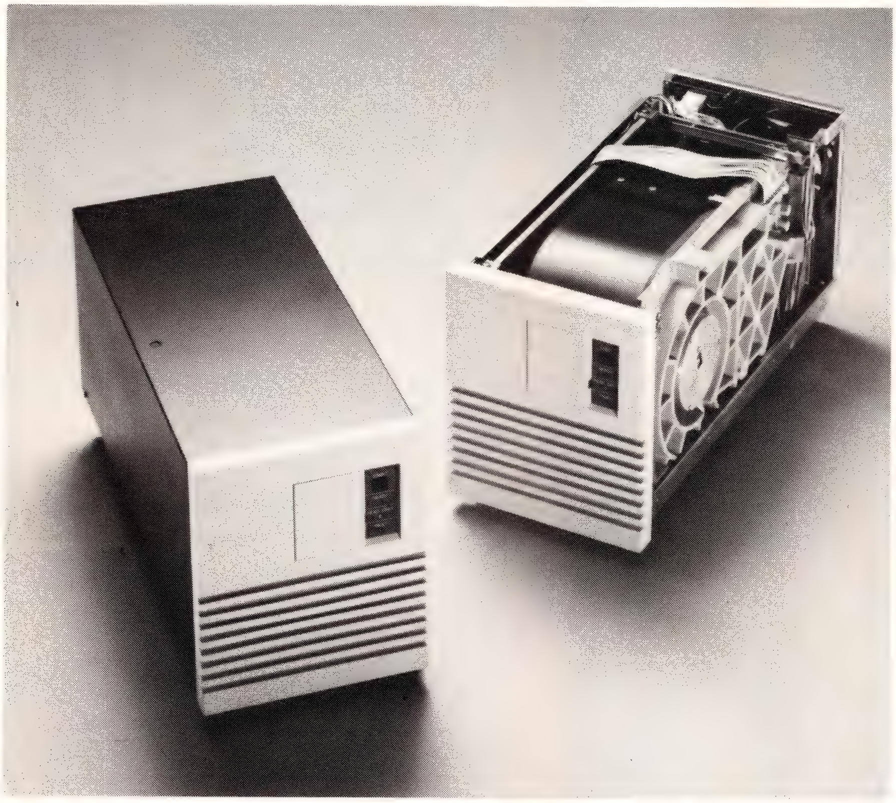
Mix bridged and embedded controllers

In bridged-controller applications, a single IPI-3/IPI-2 controller can handle eight IPI-2 devices. Some manufacturers plan to mix standards to develop products such as IPI-3/SMD controller boards, so they can take advantage of the wide availability and low cost of SMD drives. In other cases, drive or subsystem manufacturers have embedded IPI-3 I/O-bus interfaces directly in their drives. The vendors may also offer multiple devices within such embedded subsystems.

IPI-2 peripheral devices will also find application in dedicated IPI-2 controllers. For example, several controller houses plan to offer IPI-2 controllers for the VME Bus or Multibus I/II, just as they offer dedicated ESDI controllers. Finally, the IPI specification doesn't preclude mixing IPI-2 and IPI-3 devices on the same cable. The IPI-1 spec remains constant, so protocol for IPI-2 and IPI-3 is identical. A combination host adapter/controller could connect to some I/O-bus IPI-3 peripherals and some IPI-2 devices. The host adapter/controller that you build will require the intelligence to issue IPI-3 commands to the IPI-3 devices, and IPI-2 commands to the IPI-2 devices.

The IPI-3 standard I/O architecture could potentially be used as a command architecture that could control the hardware portion of other I/O standards. Dal Allan, a member of the IPI committee and the president of ENDL Inc (a Saratoga, CA, consulting firm), maintains that because IPI-3 basically defines a language or a compiler for I/O operations, you even could implement the standard for all computer operating-system I/O. By making IPI-3 independent of hardware, and by making it an industry I/O standard, a standards committee could allow software developers to write truly universal application programs.

To obtain more detailed information on the IPI standard, you can attend the IPI Forum, which is scheduled to be held March 10 through 12 in San Jose, CA. For details of the conference, contact Technology Forums, 3425 Pomona Blvd, Suite F, Pomona, CA 91768. Phone (714) 861-7300.



Packing 1G bytes into a 9-in. Winchester disk drive, *Hitachi's Model DK815-10 boasts the highest capacity available in an IPI-2 drive.*

quire only a µP, glue logic, drivers/receivers, and firmware. Simulex provides sample code to aid drive manufacturers in firmware development.

Several companies already offer IPI-2 drives. Most of the available drives were derived from SMD drives and operate at 3M bytes/sec or less, rather than near the 10M-byte/sec maximum transfer rate that IPI specifies. However, the available drives offer designers the opportunity to evaluate the IPI standard now and to begin developing IPI boards and systems.

NEC recently announced the availability of its D2362 9-in. Winchester disk drive. This IPI-2 drive stores 800M bytes in a 9-in. format. The $9500 drive features a 15-msec access time and a 2.4M-byte/sec transfer rate. NEC marketing manager John Zilinski expects that by midyear a number of manufacturers will offer drives that provide transfer rates beyond 3M byte/sec.

Control Data already offers a 3M-byte/sec drive; it stores 515M bytes. The company plans to ship the 9-in. Model FSD II drive in OEM quantities by March at $12,620.

The highest capacity IPI-2 drive available at present is the Hitachi DK815-10, which stores more than 1G byte. The 9-in. DK815-10 features a 15-msec access time and costs $14,700 in sample quantities.

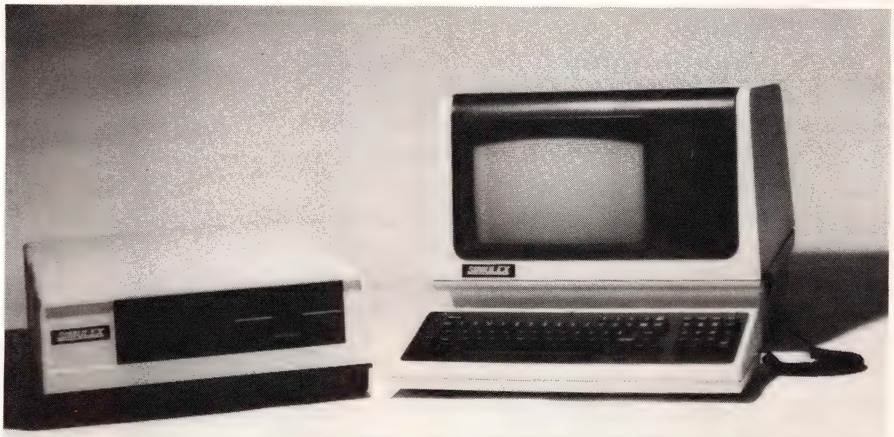
All the drives mentioned so far employ the Simulex chip set. Although it participated in the Simulex effort, however, Fujitsu designed its own chips for the M2333P, an 8-in., 337M-byte drive. The M2333P costs $4800 (100) and features 20-msec access time and a 2.5M-byte/sec transfer rate. The Simulex chips may become the yardstick for standardization, but Fujitsu hasn't decided which devices to use in its future products.

Controller choices are limited

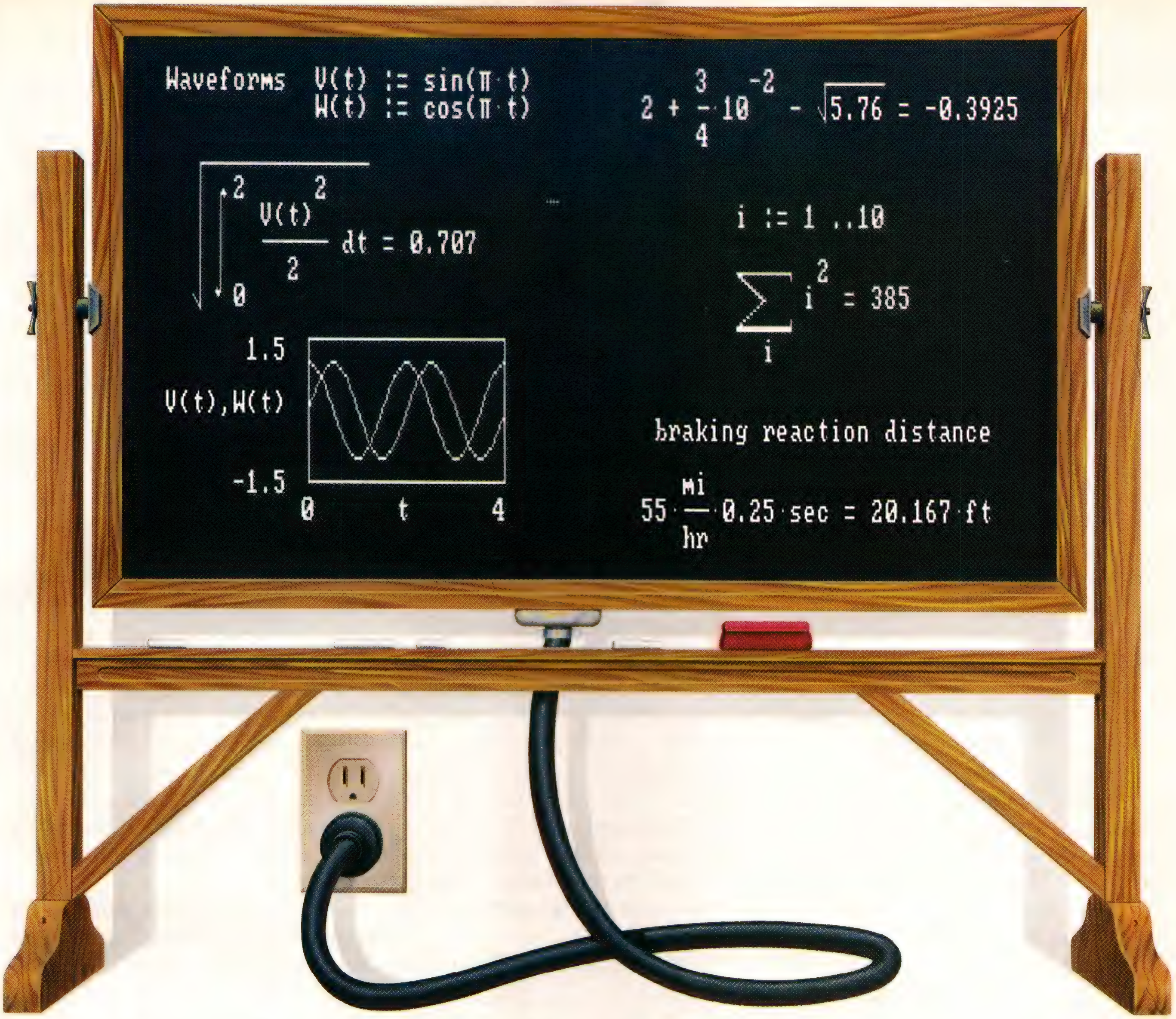
Controller boards for IPI-2 drives are still scarce; at present, only one company, Control Data, offers samples. Evaluation units of the company's Model 9057 controller and the FSD II drive sell for $17,650. The IPI-3/IPI-2 controller comes in a 3½-in.-high, 19-in.-wide rack-mountable enclosure. Control Data implemented the controller with discrete ICs. The company expects to make the controller available in production quantities in March.

Hitachi and Fujitsu both plan to offer IPI-3/IPI-2 controllers in production quantity by midyear. Hitachi plans to build its controller with discrete ICs; Fujitsu's offering will employ some custom IPI-specific ICs. Fujitsu may offer the chips commercially at a later date.

Controller houses that have experience in dedicated bus-resident controllers for SMD and ESDI peripherals plan to offer IPI-2 control-



Automatic test equipment *that simulates the master-and-slave operation specified by the IPI standard is available from Simulex. The equipment allows designers to test and debug both drives and controllers.*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W(t) := cos(π·t)
2 + 3/4 · 10^-2 - √5.76 = -0.3925
∫_0^2 V(t)^2/2 dt = 0.707
i := 1 ..10
Σ_i i^2 = 385
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V(t),W(t)
-1.5
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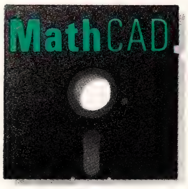

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lers also. The initial products will probably target the VME Bus and Multibus II markets. You can expect Emulex (Costa Mesa, CA), Ciprico (Plymouth, MN), Xylogics (Burlington, MA), and Interphase (Dallas, TX) to offer IPI-2 products in the second half of 1987.

IPI-3 host adapters are not available yet from any manufacturer. If you want to implement an IPI-standard system right now, you must either design your own IPI-3 host adapter or your own IPI-2 dedicated controller board.

Potential IPI-board and -system manufacturers have been hampered by the lack of IPI-compatible ICs. IPI drives and even test equipment (see **box,** "IPI test equipment") are available, but you must complete any IPI-compatible design without the aid of IPI-specific chips.

You couldn't use Simulex's IPI-2 drive chip set in a controller or a host adapter because the chips were specifically designed to implement the slave IPI-2 disk interface and not to implement a controller or other type of peripheral interface.

Simulex does, however, plan to ship ICs that target host and controller applications by midyear. The company initially plans to produce three chips for use in IPI controllers and host adapters: the SX1610 IPI-2 disk interface controller, SX1620 programmable ECC circuit, and SX1630 IPI-3 slave interface controller. **Fig 1** depicts the way the chips will be used in a typical IPI-3/IPI-2 controller with a dual-channel IPI-3 interface. The SX1610 and SX1620 also fit dedicated computer-bus-resident IPI-2 controller applications. The company currently provides circuit-board emulations of the chips.

Chips target performance gains

The three Simulex chips will initially sell for around $150 each in small quantities. Simulex president Dave Guss predicts, however, that prices could fall to the $40 range within the year. In any case, as IPI committee member Dal Allan points out, specialized ICs serve to increase performance rather than to decrease price in high-performance applications.

Furthermore, without IPI-specific ICs, you can't get high performance from a package of a reasonable size. An IPI hardware interface implemented in discrete logic is too big for use with many of today's high-performance computer systems. The controller from Control Data, for example, occupies a 19-in. rack enclosure. Although a board this size is fine for use with a mainframe system, it's much too cumbersome for use with a workstation. When IPI-specific ICs are available, you'll be able to build a controller board that fits into the case that houses the disk drive.

Several companies besides Simulex have also developed discrete implementations of IPI-3 in I/O subsystems or computer systems. Century Data Systems, for example, offers IPI-3 subsystems with capacities ranging from 344M bytes to almost 3G bytes. The subsystems start at $12,000 to $13,000 and contain from one to eight drives each. A full subsystem resembles two filing cabinets.

IBM offers IPI-3 disk subsystems for its System 36 and 38 computers; the company also sells the subsys-

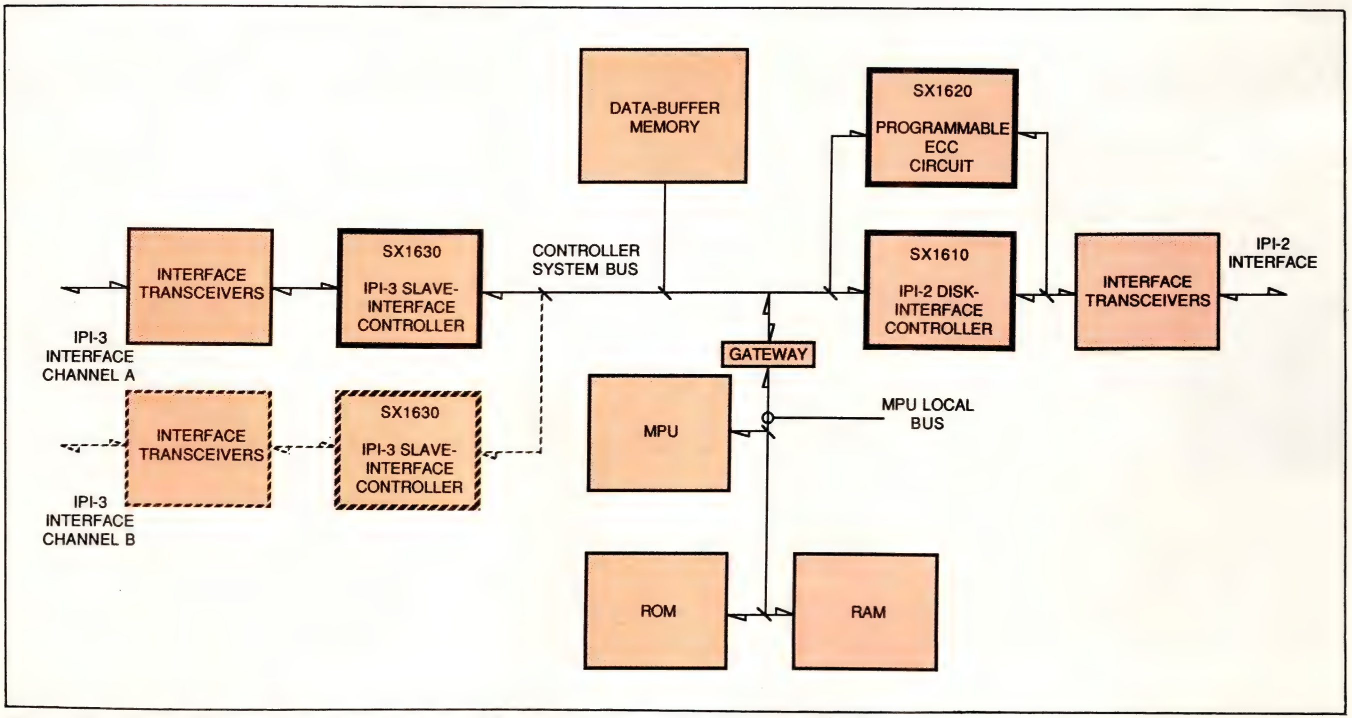

*Fig 1—**The three IPI-specific chips** planned by Simulex will simplify the design of IPI-3/IPI-2 controllers and dedicated IPI-2 controllers. The block diagram shows a typical IPI-3/IPI-2 implementation.*

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Automatic test equipment that can simulate IPI environments is available from Simulex. The testers simulate master and slave IPI environments for testing drives, controller boards, or host adapters. The testing devices run at the full 10M-byte/sec data-transfer rate specified in the ANSI document.

Currently, you can choose from one of three IPI test sets. Model 4711 includes a single IPI channel that can be operated in master or slave mode. You develop test software for the system by using a proprietary high-level language. The system includes Winchester and floppy-disk drives. The system targets applications requiring extensive software development.

For less-extensive program development, Model 4702 provides more sophisticated IPI capabilities without the Winchester drive. The tester includes two IPI channels, each of which can be operated in master or slave mode. In fact, you can test an IPI-3/IPI-2 controller board by plugging the IPI-3 side into one port and the IPI-2 side into the other.

The 4711 and 4702 sell for $31,000 each, and each includes an internal logic analyzer and a graphics terminal. Simulex also offers the $8000 Model 2701 IPI tester in a portable "suitcase" package. The 2701 has no program-development capabilities, and it operates in master mode only. The suitcase model, which executes software developed on one of the other testers, is suitable for field testing or factory applications. The manufacturer also offers programs, such as an IPI-2 disk-validation program, that run on the testers.

tems as OEM products. The Model 9332 costs $8500 and stores 200M bytes, and the 400M-byte 9335 approaches the $30,000 range. Both drive subsystems fit into 19-in. racks. Although it participated in the development of the Simulex chips, IBM hasn't yet announced an IPI-2 product. However, the fact that IBM offers both IPI-3 disk subsystems and an IPI-3 interface on its System 36 and 38 computers indicates that the company will probably make a major commitment to IPI products.

You can purchase an IPI-3 tape subsystem for the System 36 and 38 computers from IBM, although Cipher Data actually manufactures the product. (Cipher markets the tape subsystem under the name IPI Microstreamer.) The ½-in. reel-to-reel tape drive accepts 7- or 10-in. reels and stores 46M bytes on a 2400-ft tape. The drive employs phase encoding at 1600 bpi and sells for $3000 (100).

Two other major companies also plan to use IPI-3 in their systems and subsystems: Siemens (Boca Raton, FL) and Gould (Fort Lauderdale, FL) both have IPI-3 products in the works. In fact, both companies have developed custom ICs for the IPI-3 interface, and you can expect the companies' US IC divisions to offer those ICs later this year.

The IPI is still a very young standard, but it already has a lot of momentum. By the end of the year, you can expect IPI products to be commonplace; in 1988, IPI products will dominate the high-end I/O market. IPI committee member Dal Allan believes that IPI is one of very few standards to arrive concurrently with both the need for it and the technological capability of implementing it.

Allan also points out that the committee intends to enhance IPI to keep up with technological advancements. The ANSI group is already planning to double the transfer rate and to increase the width of the data path to 128 bits. The use of fiber-optic cables instead of ribbon cables in the physical interface may also enhance performance. Such improvements will allow the manufacturers to employ the IPI standard in parallel-transfer disk (PTD) drives and possibly even in multiple 5¼-in. Winchesters that operate in parallel. **EDN**

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For more information . . .

For more information on the IPI products discussed in this article, contact the following manufacturers directly or circle the appropriate numbers on the Information Retrieval Service card.

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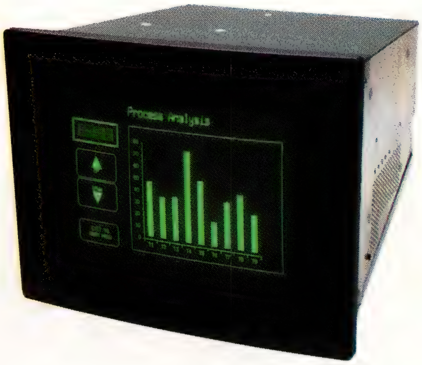

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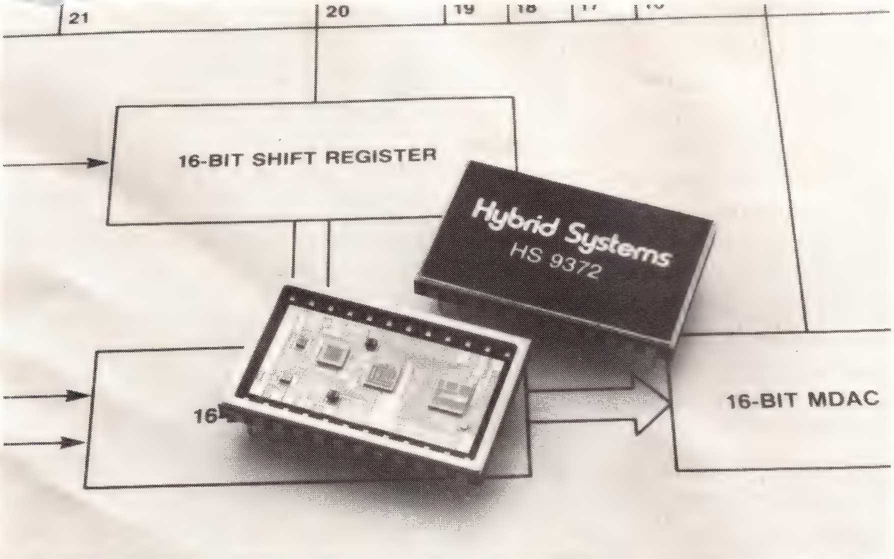

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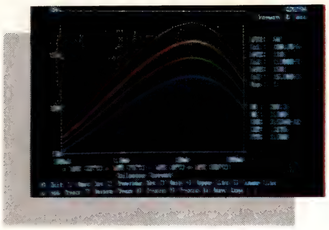

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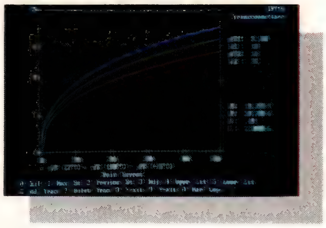

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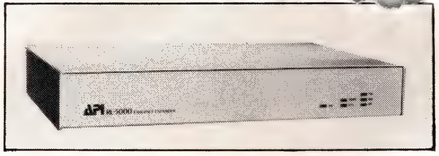

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You can simplify a wide variety of Ethernet interconnections by using the RL5000 Model 2. In the simplest application, the system can provide network access to a workstation located outside the 50m transceiver-cable limit. In a multiple-workstation application, you can connect the remote RL5000 directly to a multiport expansion device such as the DEC DELNI. You can also connect the expander to remote asynchronous terminals via an Ethernet terminal server and use the network to access distant mainframes.

The RL5000 Model 2 can also be used with Ethernet bridging or gateway equipment to interconnect two distant Ethernet networks. For networks that have no coax cable, the Expanders can provide a high-quality, high-speed link between two Ethernet-compatible devices such as mainframe computers. Although your link's transmission distances can exceed 3 km, you must not exceed the specified round-trip delay times in larger networks.

The expander system consists of two identical Interface units and a 2-fiber optical cable. You can use the Interface units interchangeably at either the station controller or the transceiver. The Interface unit used at the transceiver also powers the transceiver.

The RL5000 Model 2 is compatible with a variety of standard fiber diameters—50, 62.5, 85, and 100 μm. The link optical power margin specs at 10 dB min. The steady-state propagation delay is 100 nsec for the Interface unit and 4.94 nsec/m for the cable. The operational wavelength is 820 nm. The RL5000 operates from standard ac line inputs and consumes 40W.

Internal fusing and overvoltage protection are standard. The system operates over 0 to 50°C. Its optical connectors are SMA types. For the electrical interface, the transceiver-type interface units have 15-pin D subminiature female connectors; the station-controller units have 15-pin male D subminiature connectors. The RL5000 is available in standalone or 19-in. rack-mount configurations. $2250. Delivery, four to six weeks ARO.—***Tom Ormond***

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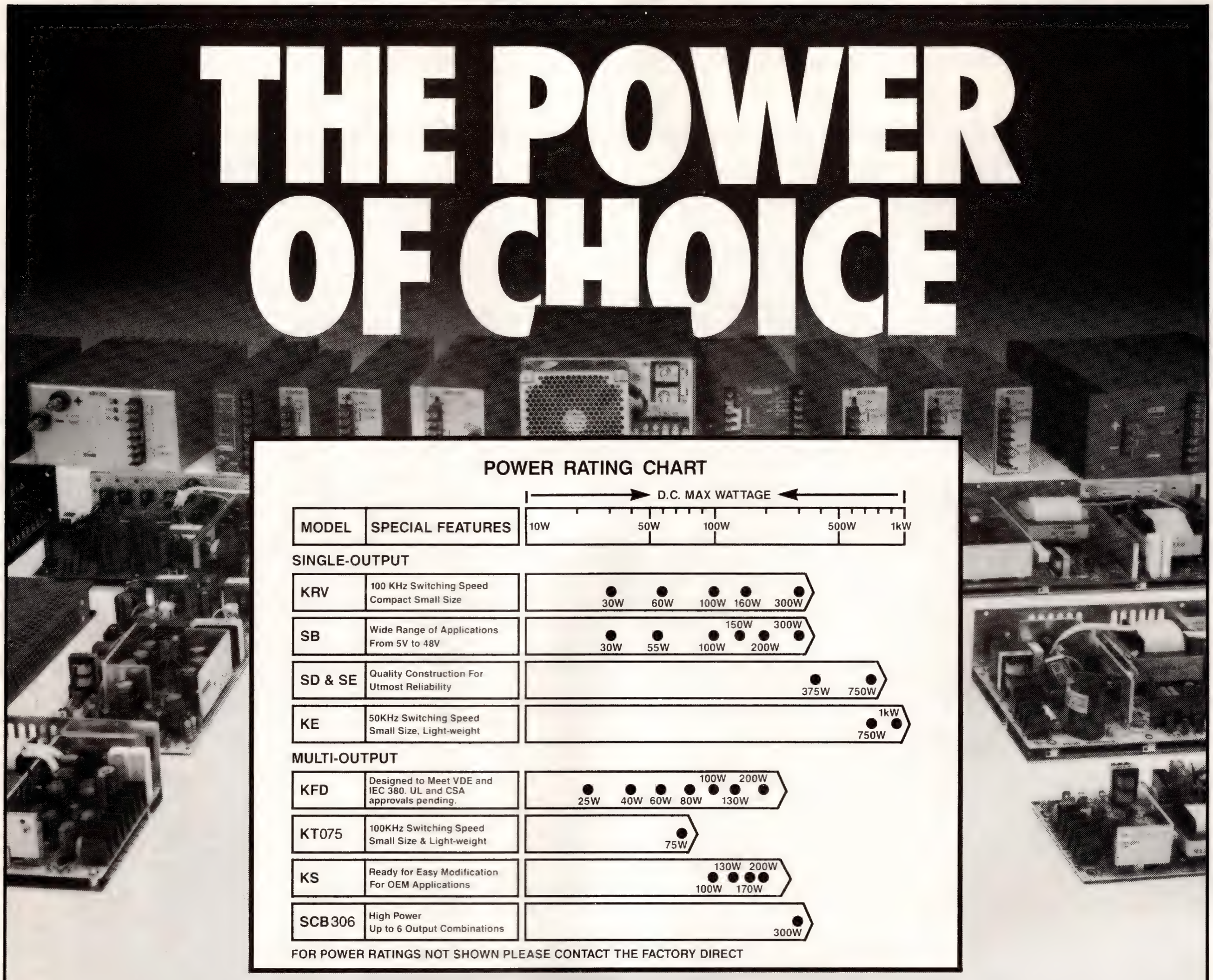
CIRCLE NO 150

THE POWER OF CHOICE



POWER RATING CHART

MODEL	SPECIAL FEATURES	D.C. MAX WATTAGE (10W – 1kW)
SINGLE-OUTPUT		
KRV	100 KHz Switching Speed Compact Small Size	30W, 60W, 100W, 160W, 300W
SB	Wide Range of Applications From 5V to 48V	30W, 55W, 100W, 150W, 200W, 300W
SD & SE	Quality Construction For Utmost Reliability	375W, 750W
KE	50KHz Switching Speed Small Size, Light-weight	750W, 1kW
MULTI-OUTPUT		
KFD	Designed to Meet VDE and IEC 380. UL and CSA approvals pending.	25W, 40W, 60W, 80W, 100W, 130W, 200W
KT075	100KHz Switching Speed Small Size & Light-weight	75W
KS	Ready for Easy Modification For OEM Applications	100W, 130W, 170W, 200W
SCB306	High Power Up to 6 Output Combinations	300W

FOR POWER RATINGS NOT SHOWN PLEASE CONTACT THE FACTORY DIRECT

KEC PRECISION SWITCHING POWER SUPPLIES

Now KEC gives you the power of choice with over 100 power supplies for every conceivable application. KEC's standard line includes both single and multi-output units in open frame and modular enclosed styles. And if you require something more than standard—KEC can quickly customize even a single unit for your application.

One example of KEC's exciting line: the KFD world-class power supply family, including 23 models in 7 different wattages from 25 to 200W. All are designed to meet VDE safety requirements (UL, CSA, TÜV approved or pending). Each is optimum for use with microperipheral equipment. And all feature low profile, small size, EMI emissions that are in compliance with VDE/FCC specifications, and more than competitive pricing.

Another example of the KEC difference: the new KE series of single output 1000W, 50KHz switching power supplies optimum for test equipment and main frame computers. These high power, fan cooled units feature: compact size, low cost, UL approval (CSA pending), enhanced reliability, rugged construction, 115 VAC and 230 VAC inputs, built-in overload protection, conformance to FCC Class A on conductive noises, plus remote programming, test and shutdown capability.

But whatever the power supply—KEC is always the supplier of choice when it comes to exceptional quality. It's a fact: KEC gets less than 1% field returns! Why? Every unit is MTBF calibrated... individually tested... built with a 20 to 25% safety margin... burned-in for 72 hours... and backed with a full two year warranty.

For the full story on the KEC power supply line, send for a free brochure and information packet today. **KEC Electronics, Inc.**, 20817 Western Avenue, Torrance, CA 90501. **(213) 320-3902.**

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CIRCLE NO 96

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Reader Vote No. 9009

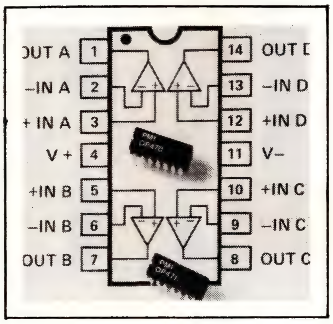
CIRCLE NO 63

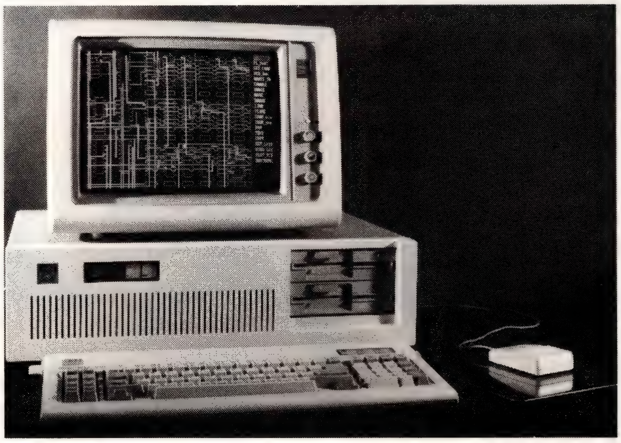
READERS' CHOICE

Of all the new products covered in EDN's **October 30, 1986,** issue, the ones reprinted here generated the most reader requests for additional information. In case you missed them the first time, find out what makes them special: Just circle the appropriate numbers on the Information Retrieval Service card, or refer to the indicated pages in our **October 30, 1986,** issue.

AMPLIFIER ▶

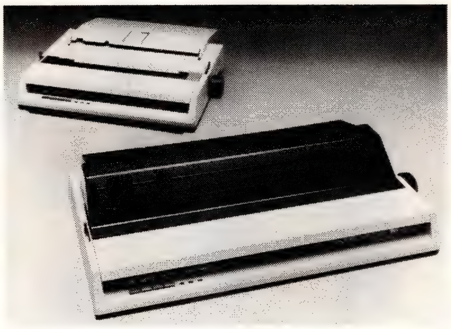
Model OP-470 boasts the lowest guaranteed noise of any available quad operational amplifier and delivers performance comparable to that of the manufacturer's industry-standard OP-27 (pg 117).
Precision Monolithics Inc.
Circle No 401





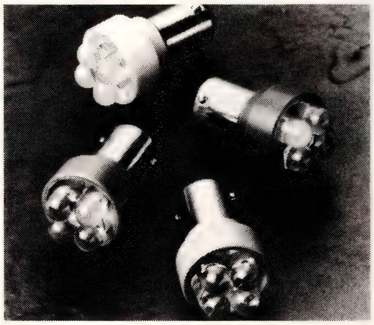
200-CPS PRINTERS ▶

The 192 Plus and the 193 Plus printers feature 9-pin printheads and offer menu-selectable print modes with speeds ranging from 40 to 200 cps (pg 225).
Okidata.
Circle No 403



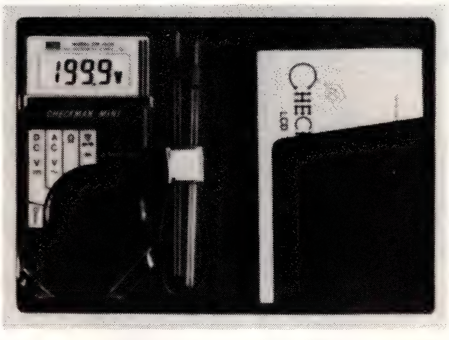
▲ PC-BOARD ROUTER

Running on AutoCAD, AutoPCD consists of integrated schematic-capture and pc-board-layout packages to combine any of four routing strategies (pg 215).
Pro.Lib Inc.
Circle No 402



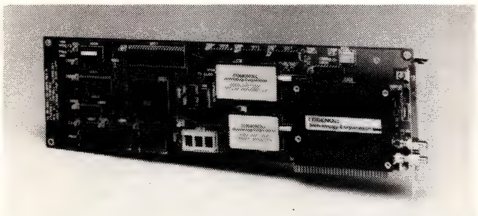
POCKET DMM ▶

The Checkman Mini, Model DM1000, is a card-size 3½-digit multimeter that comes in a vinyl case and has attached probes (pg 263).
Siber Hegner North America Inc.
Circle No 406



▲ LED ILLUMINATORS

MX400 Series LED illuminators are brighter than the equivalent-sized incandescent lamps and have bases that are compatible with those lamps (pg 236).
Data Display Products.
Circle No 404



◀FIBER-OPTIC ADAPTER

The CN-3051 adapter board, operating on a fiber-optic network, allows IBM PCs and compatibles to communicate over distances as great as 200m (pg 253).
Codenoll Technology Corp.
Circle No 405

MICROTEK DOES IT AGAIN

...AT THE LEADING EDGE
SUPER 8, 68020,
NOW 80386!

The Intel 32-bit 80386 microprocessor has arrived, and is set to play an important role in high-end, high-performance products. Due to wider buses and higher clock speeds, complex 80386 target systems now require more powerful developing and debugging tools. Selection of a good development system and emulator will be critical in determining whether or not 80386-based products are completed on schedule and within budget.

MICROTEK'S U.S. service, sales and marketing arm, NEW MICRO, now has the MICE-32/80386, a portable emulator that can run with any IBM-PC/XT/AT personal computer or compatible, VAX, and MicroVAX through parallel or serial interface. Or can stand alone with a terminal.

Look at these features:
- *Completely self-contained standalone emulator*
- *User-friendly command structure*
- *Emulation to 32 MHz*
- *"Snapshot" conditional, time-stamped trace*
- *256K Bytes soft mapped emulation memory*
- *Powerful symbolic debugger with user definable procedures under PC/MSDOS, VMS and ULTRIX.*

Other processors supported by Microtek
80286, 80186, 80188, 8086, 8088, 68000, 68010, 68008, Z80, NSC800, 8085, 6809, 6809E, 6502 (40 and 28 PIN) 8032, 8051, 8031, 8344, 8048, 8049, 8050, Z8, SUPER 8

NMI

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Gardena, CA 90247
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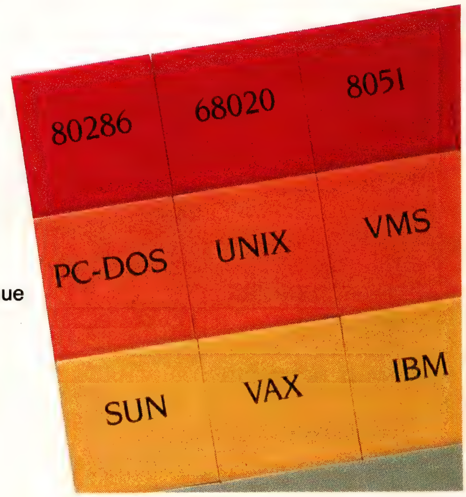
In CA: (213) 538-5369



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CIRCLE NO 98

LEADTIME INDEX

Percentage of respondents

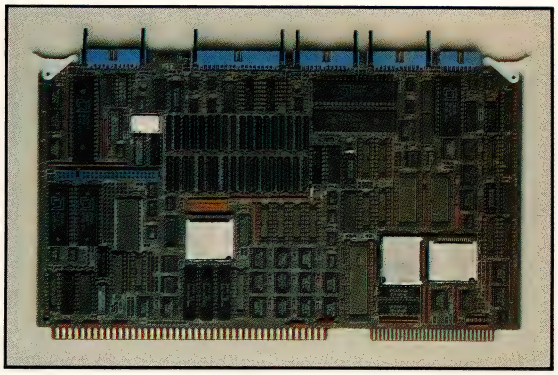
ITEM	Off the shelf	1-5 weeks	6-10 weeks	11-20 weeks	21-30 weeks	Over 30 weeks	Average (weeks)	Last month's average (weeks)
TRANSFORMERS								
Toroidal	7	27	47	13	6	0	8.1	8.1
Pot-Core	0	33	34	17	8	0	8.2	6.9
Laminate (power)	5	36	36	18	5	0	7.7	9.0
CONNECTORS								
Military panel	0	22	56	11	11	0	9.6	3.6
Flat/Cable	23	50	18	9	0	0	3.9	3.4
Multipin circular	7	13	60	13	7	0	8.9	4.0
PC	12	41	29	18	0	0	6.0	5.1
RF/Coaxial	23	53	6	18	0	0	4.4	1.8
Socket	17	48	22	13	0	0	4.7	4.7
Terminal blocks	15	48	33	4	0	0	4.2	4.1
Edge card	15	50	20	10	5	0	5.5	6.1
Subminiature	10	40	35	10	5	0	6.5	5.1
Rack & panel	8	46	31	15	0	0	5.8	7.4
Power	14	50	22	7	7	0	5.7	5.0
PRINTED CIRCUIT BOARDS								
Single-sided	0	50	45	5	0	0	5.4	4.9
Double-sided	0	62	38	0	0	0	4.3	5.1
Multilayer	0	30	57	13	0	0	7.2	7.1
Prototype	0	89	11	0	0	0	2.7	2.2
RESISTORS								
Carbon film	50	24	21	6	0	0	3.1	2.2
Carbon composition	37	21	21	21	0	0	5.4	4.0
Metal film	38	27	29	6	0	0	3.8	3.8
Metal oxide	36	18	37	0	9	0	5.6	5.3
Wirewound	25	17	46	8	4	0	6.4	7.7
Potentiometers	23	20	40	13	4	0	6.6	7.7
Networks	31	27	31	4	7	0	5.6	5.2
FUSES	48	23	26	3	0	0	3.0	2.7
SWITCHES								
Pushbutton	20	33	40	7	0	0	4.9	5.4
Rotary	5	45	45	5	0	0	5.3	6.1
Rocker	17	39	35	9	0	0	5.0	4.6
Thumbwheel	13	27	33	27	0	0	7.5	8.2
Snap action	33	25	33	8	0	0	4.5	6.9
Momentary	7	43	43	7	0	0	5.4	5.7
Dual in-line	17	41	25	17	0	0	5.5	5.7
WIRE AND CABLE								
Coaxial	44	22	28	6	0	0	3.6	1.9
Flat ribbon	30	44	22	0	4	0	3.6	2.5
Multiconductor	23	53	18	0	6	0	4.0	1.6
Hookup	48	42	10	0	0	0	1.7	1.5
Wire wrap	40	33	27	0	0	0	2.8	2.1
Power cords	25	36	32	7	0	0	4.4	3.5
Other	0	80	20	0	0	0	3.2	5.3
POWER SUPPLIES								
Switching	0	25	50	20	5	0	9.0	5.2
Linear	11	22	44	17	6	0	8.1	4.8
CIRCUIT BREAKERS	17	31	35	13	4	0	6.6	5.7
HEAT SINKS	24	40	28	8	0	0	4.3	3.5

ITEM	Off the shelf	1-5 weeks	6-10 weeks	11-20 weeks	21-30 weeks	Over 30 weeks	Average (weeks)	Last month's average (weeks)
RELAYS								
General purpose	23	27	31	15	4	0	6.5	5.5
PC board	14	27	27	27	5	0	8.3	7.1
Dry reed	18	9	37	27	9	0	10.0	8.7
Mercury	11	22	22	34	0	11	11.0	6.0
Solid state	17	33	17	28	0	5	8.2	7.6
DISCRETE SEMICONDUCTORS								
Diode	39	21	32	5	3	0	4.5	3.4
Zener	30	28	30	12	0	0	4.9	5.0
Thyristor	19	38	25	12	6	0	6.4	4.5
Small signal transistor	35	15	25	20	0	5	7.1	5.1
FET, MOS	5	45	30	10	5	5	7.8	7.1
Power, bipolar	31	25	38	6	0	0	4.5	6.7
INTEGRATED CIRCUITS, DIGITAL								
CMOS	11	33	34	15	7	0	7.6	4.5
TTL	36	24	32	4	4	0	4.7	4.5
LS	29	26	37	4	4	0	5.0	4.3
INTEGRATED CIRCUITS, LINEAR								
Communication/circuit	14	14	58	7	7	0	7.9	4.0
OP amplifier	11	31	31	23	0	4	8.0	6.5
Voltage regulator	19	35	23	19	0	4	6.8	4.5
MEMORY CIRCUITS								
RAM 16k	17	25	33	17	0	8	8.4	4.6
RAM 64k	19	38	25	12	0	6	6.7	4.5
RAM 256k	23	12	47	12	0	6	7.7	5.8
ROM/PROM	25	8	50	8	0	9	8.0	7.2
EPROM	13	33	33	17	0	4	7.3	5.5
EEPROM	19	19	37	19	0	6	8.3	7.8
DISPLAYS								
Panel meters	13	40	40	0	7	0	5.7	5.6
Fluorescent	20	10	30	30	10	0	10.0	8.5
Incandescent	25	0	50	12	13	0	9.3	8.4
LED	14	36	39	7	4	0	5.9	4.9
Liquid crystal	7	7	66	20	0	0	8.7	7.8
MICROPROCESSOR ICs								
8-bit	25	19	38	12	0	6	7.3	7.1
16-bit	5	32	42	16	0	5	8.2	4.3
FUNCTION PACKAGES								
Amplifier	28	18	27	18	0	9	8.3	6.0
Converter, analog to digital	0	37	18	36	0	9	10.8	10.2
Converter, digital to analog	0	20	50	20	0	10	10.7	11.3
LINE FILTERS	9	36	37	9	9	0	7.5	5.3
CAPACITORS								
Ceramic	23	33	34	10	0	0	4.9	5.0
Ceramic monolithic	12	38	42	8	0	0	5.4	5.5
Ceramic disc	17	42	29	8	4	0	5.6	4.3
Film	19	27	31	23	0	0	6.7	4.4
Electrolytic	17	34	31	14	4	0	6.3	6.3
Tantalum	19	23	36	19	3	0	7.2	6.3
INDUCTORS	12	24	35	23	6	0	8.6	6.3

Source: *Electronics Purchasing* magazine's survey of buyers

The Better 80286 and 8086 Single Board Computers

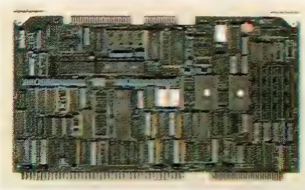
New from Central Data



Two boards-in-one performance with one 80286-based processor board—and all at one low price.

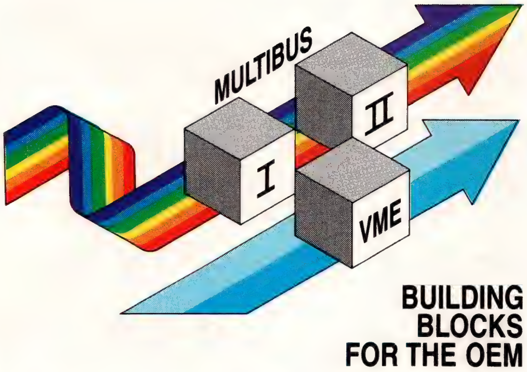
Central Data's engineers have designed more power and more features into smaller Multibus* system space with our new 80286 Single Board Computer. Fully plug-compatible with Intel's 286/12, 286/10, and 286/10A, Central Data's 80286 delivers the features and performance your application requires at a more attractive price.

Designed around an 8MHz 80286 microprocessor with memory management, the 80286 Single Board Computer includes a CPU and memory—and a record number of on-board features. The board delivers up to one megabyte of zero-wait-state, dual-ported RAM, and uses only one slot in your system cabinet, instead of the two slots required by the Intel 286/12. The Central Data 80286 also includes interfaces for the 80287 numeric data processor, eleven DMA channels, an LBX bus interface, an SBX connector, and more. For design flexibility, one of the board's four RS-232 serial I/O ports can be configured for RS-422.



And another top price performer on the Multibus:

Central Data's **8086 Single Board Computer** is the industry's top performer in 86/30 and 86/35-based applications, delivering 30% to 40% greater performance than similar boards on the market. Available in two versions, both are fully Intel-compatible, yet technically superior and competitively priced. The 8086 delivers up to one megabyte of on-board RAM with zero-wait-states at 5, 8 and 10 MHz operation, all strap selectable. Other high performance design features include a large memory capacity, parity checking, two SBX connectors and a built-in socket for the 8087 numeric data processor.



Central Data

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Champaign, IL 61821-1098
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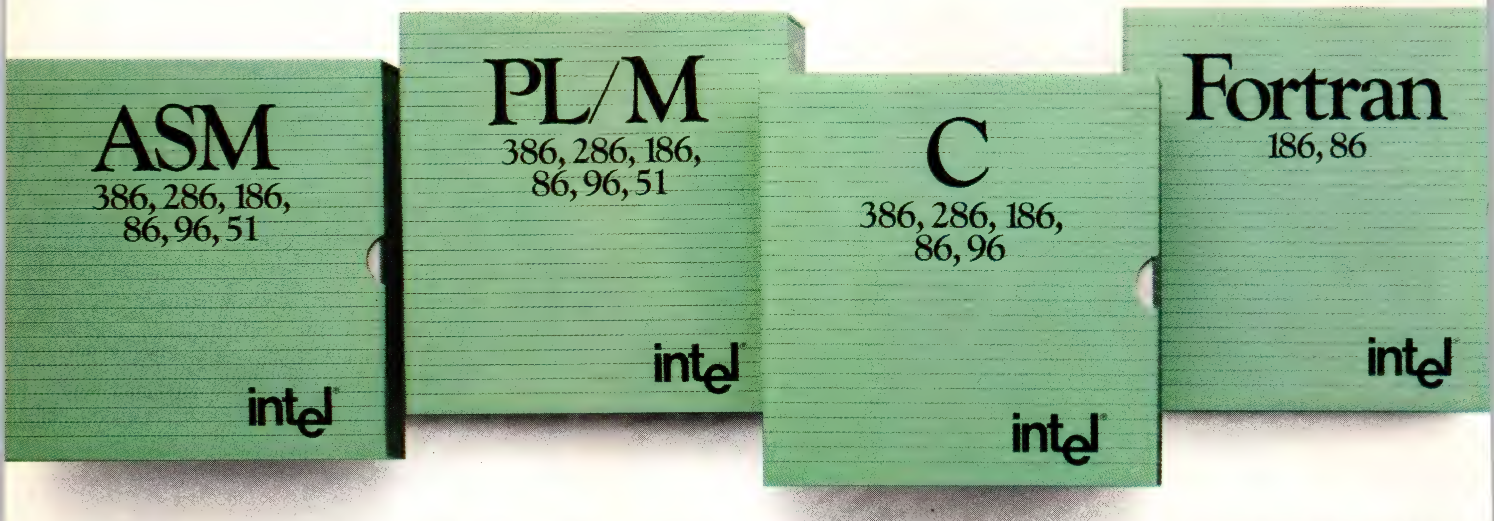
CIRCLE NO 95

WRITE FASTER IN ANY LANGUAGE.



If you develop software for any product based on an Intel microcontroller or microprocessor, including the 80386, the unique debug hooks in the Intel languages will help get the job done faster.

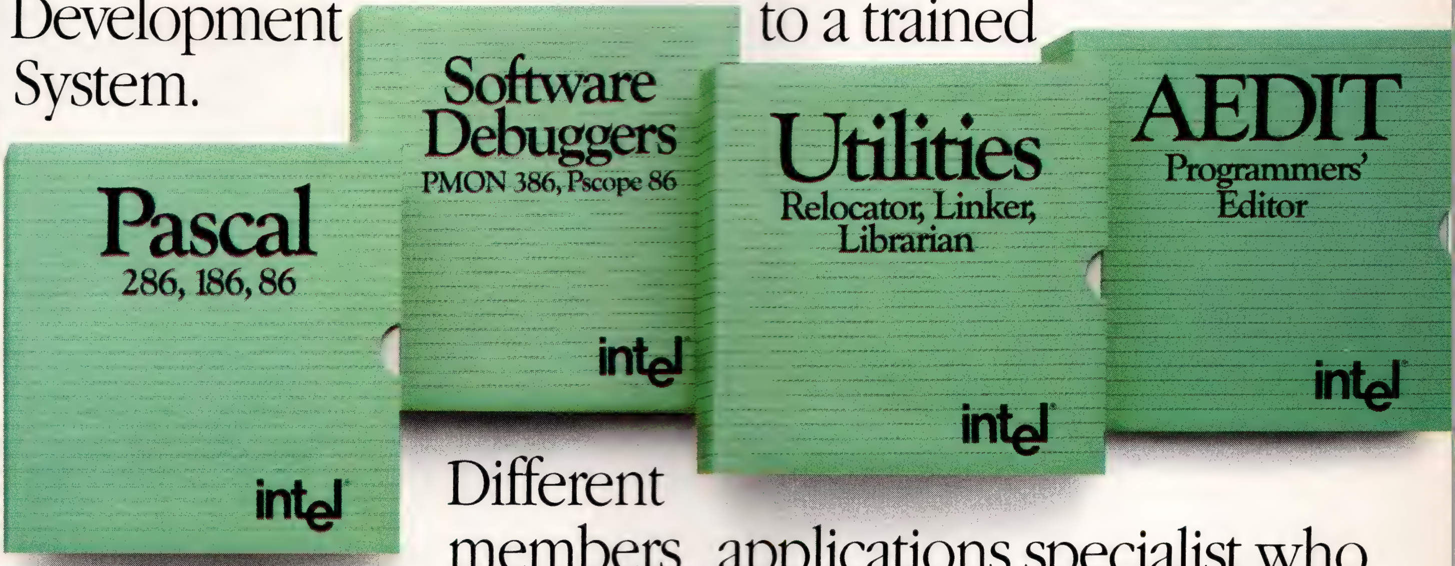
In fact, when used with Intel debuggers and emulators, Intel development languages can provide more debug data than any other high-level language.

Debug hooks let you symbolically debug in the same high-level language you wrote in without having to deal with machine or hex code. Which means 80.386 reads as 80.386, not 50 62 D0 C5.

Because the location of both code and data are easily specified with our locator, it is easier for you to develop ROM-based firmware.

Since Intel languages

produce identical object code regardless of the host, you can write code at a PC running DOS, a VAX*/VMS terminal, or an Intel Development System.



Different members of the same design team can therefore choose the most effective combination of languages and systems to get the job done faster.

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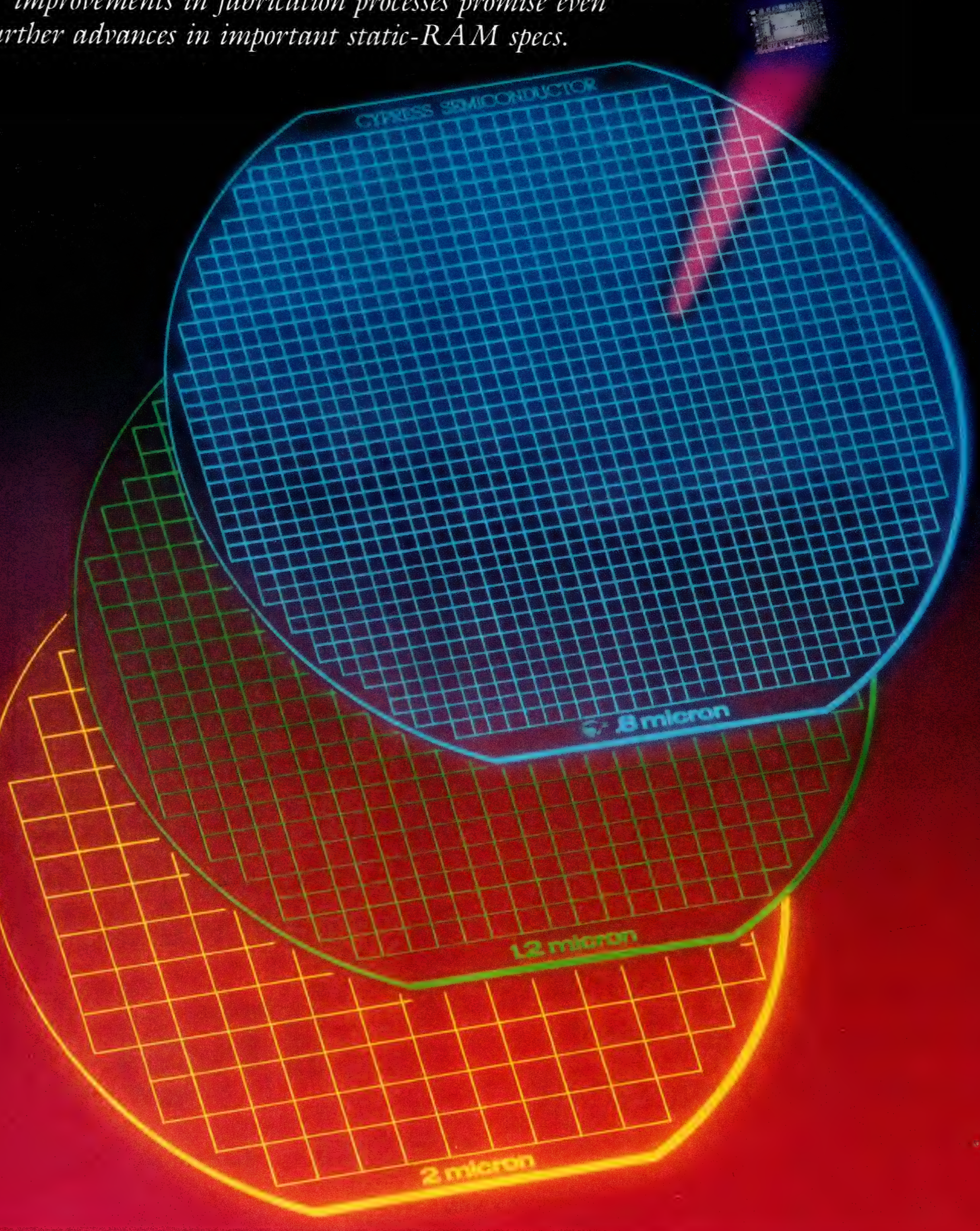
CIRCLE NO 100

Static RAMs

Innovation is driving the market for static RAMs, providing designers with an assortment of memory devices that sport a variety of features—including speed/density combinations that challenge dynamic-RAM performance. Continuing improvements in fabrication processes promise even further advances in important static-RAM specs.



Special Report

J D Mosley, *Regional Editor*

Once ignored by design engineers, who weren't willing to sacrifice memory speed, density, and price for ease of integration, static RAMs now offer features and levels of performance that make these devices a practical alternative to low-cost dynamic RAMs. Although static RAMs remain a generation behind dynamic RAMs with respect to speed and density, 256k-bit densities and access times under 10 nsec make monolithic static RAMs acceptable for a variety of applications. Furthermore, because static RAMs are easy to customize, many companies offer their static RAMs with a number of application-specific features.

Processes offer differing benefits

Bipolar memories using emitter-coupled logic (ECL) provide the fastest access times available in a static RAM, but ECL parts consume two to three times more power than those slower MOS RAMs that use TTL-compatible circuitry. Bipolar static RAMs also require larger die sizes than MOS memories—an important consideration if you have little board space to spare.

Although TTL-compatible static RAMs are fabricated using bipolar, NMOS, and CMOS processes, CMOS versions predominate. CMOS technology, however, is often associated with quality and reliability problems stemming from its high susceptibility to electrostatic discharge (ESD) and latch-up. The gate-oxide breakdown characteristics of CMOS, coupled with its high input impedance, makes this process a prime candidate for ESD damage.

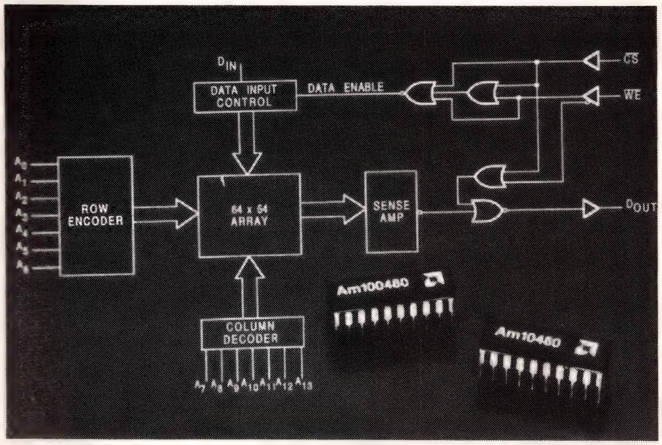
Every IC manufacturer has taken steps to reduce the possibility of chip failure arising from ESD. Harris Semiconductor, for example, uses a junction-isolated dual-diode protection network on its line of CMOS memories. Other manufacturers, such as Integrated Device Technology, use this type of protection network and add proprietary circuitry on device outputs to protect against ESD stress and device degradation. All manufacturers, however, warn that careful handling of static-sensitive ICs is imperative. It's also interesting to note that some bipolar devices are now more sensitive to ESD than their CMOS counterparts because of new processing technologies involving shallow junctions.

The other familiar CMOS problem, latch-up, occurs when the CMOS substrate's parasitic resistance (R_{SUB}) isn't properly grounded, causing a current to flow from ground. Depending on the device's sensitivity, this current can forward-bias transistors in the device, resulting in a current surge that can destroy the IC.

Latch-up can occur in response to currents as low as a few milliamperes, or it may require several hundred milliamperes of sink or source current. To minimize the effects of the latch-up phenomenon, Cypress Semiconductor uses design techniques—including a low-impedance substrate and a substrate bias generator—that move the trigger threshold far beyond the operating range of the device. These improvements also result in a higher noise tolerance.

Another problem associated with the miniaturization of IC memories involves soft errors—that is, transitory memory failures caused by alpha particles emitted by the IC's packaging materials. These particles can cause data reversion in the memory. If high reliability is a major design concern, you may want to make sure that the manufacturer has taken steps to prevent soft errors. Such measures include the use of packaging materials having minimal alpha-particle emissions, application of a chip coating that's resistant to alpha particles, and design of a circuit that inherently resists alpha particles.

One such circuit is called a 6-T (6-transistor) cell. Most CMOS cells have four transistors (4-T) and two polysilicon pullup resistors. Because transistors are more resistant to alpha-particle radiation and temperature variations than resistors, 6-T cells replace the two pullup resistors with transistors and thus reduce the



***Using a bipolar process that provides 1.2-μm feature sizes** and a "slot" that lowers parasitic capacitance, the 16k×1-bit Am10/100480 from AMD boasts a 15-nsec access time.*

***Shrinking geometries** are propelling static RAMs into high-performance applications. (Photo courtesy Cypress Semiconductor)*

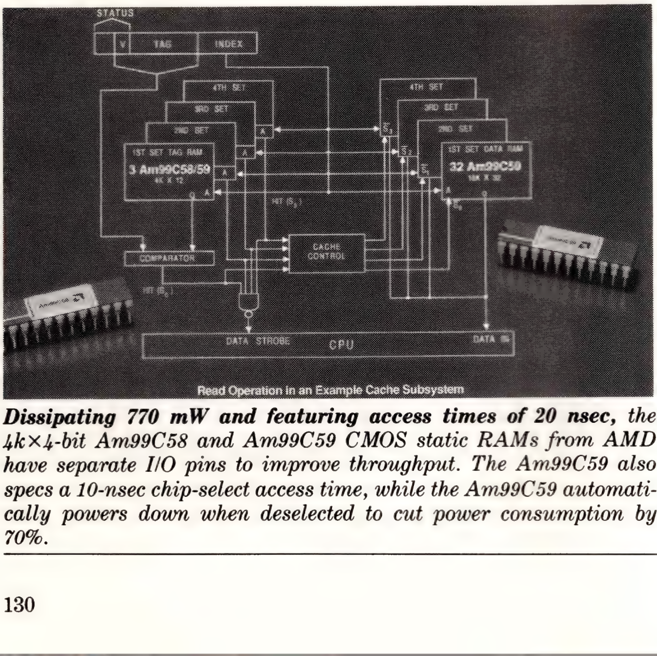
Some bipolar devices are now more sensitive to ESD than their CMOS counterparts, a result of new processing technologies involving shallow junctions.

possibility of soft errors. An added bonus is reduced power consumption.

These challenges to the ingenuity of MOS memory manufacturers and designers have resulted in an interesting side benefit. Recognizing the lengthy development cycles that are common among the established semiconductor firms, a number of US start-up companies have rushed into the breach and given designers state-of-the-art memories specifically intended for cutting-edge applications. The memories these start-ups offer tend to be low-density, high-speed, application-specific devices that are produced in low volumes, but they do let designers build prototype designs that are on the leading edge of technology. By the time you're ready to mass-produce the prototype, the major semiconductor companies should be able to fulfill your needs.

Cypress is one of these newer companies. Founded in April 1983, Cypress has supplied high-performance CMOS memories that range in density from 64 to 64k bits and in access time from 15 to 35 nsec. Cypress is now working on the CY7C123, a 256×4-bit CMOS static RAM with a 7-nsec access time. Scheduled for introduction in the first quarter of 1987, this 24-pin IC will come in a 300-mil package and will feature separate TTL-compatible inputs and outputs. It promises to withstand greater than 2000V of static discharge. Pricing is not yet available.

Another company that makes ASIC memories, VLSI Technology, prides itself on its ability to take a product from concept to market in only six months (established semiconductor manufacturers can take two years to introduce a new product). VLSI Technology recently acquired another start-up company, VISIC Inc, to expand its design capacity and strengthen its ability to explore new technologies.



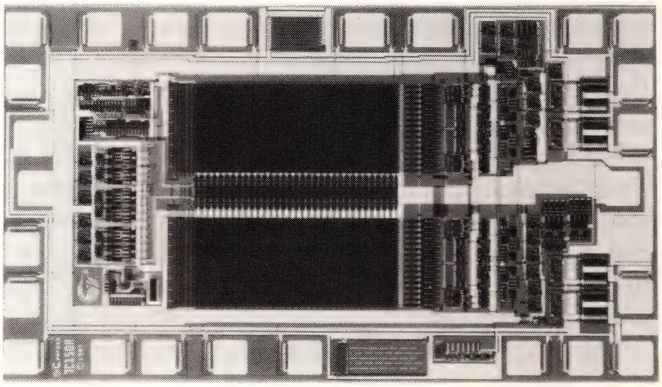
***Dissipating 770 mW and featuring access times of 20 nsec,** the 4k×4-bit Am99C58 and Am99C59 CMOS static RAMs from AMD have separate I/O pins to improve throughput. The Am99C59 also specs a 10-nsec chip-select access time, while the Am99C59 automatically powers down when deselected to cut power consumption by 70%.*

Interface between 8- and 16-bit μPs

Although the company does market some standard RAMs, VLSI Technology prefers to focus on chips like its multiplexed dual-port static RAM, the VT16DP8. This IC's left port is organized as 1024 16-bit words, while the right port can hold 2048 8-bit words. This design lets you use the VT16DP8 as a single-chip interface between 16- and 8-bit μPs. Its 60-nsec access time, an output enable on each port, and separate power-down functions for each port further simplify your circuit-design requirements. Other features include on-chip contention logic, which arbitrates between attempts to access the memory; it delays requests for one port until an operation using the other port is complete. Pricing starts at $52.60 (1000).

If you need a fast CMOS dual-port static RAM that isn't quite as exotic as the VT16DP8, consider Mosel's 45-nsec 2k×8-bit device. This chip consumes only 325 mW during operation and 5 mW in standby mode. Alternatively, you can order a low-power version that consumes 200 μW of battery power in the standby mode. Each port has separate controls, a separate address, and separate inputs and outputs, which together allow independent access for read or write operations to any location in memory. Housed in a 48-pin, 600-mil DIP, the MS6132 costs $35 (100).

Another start-up company that's carving out a market niche by avoiding commodity products and beating the major semiconductor companies to market is Integrated Device Technology. One noteworthy CMOS stat-

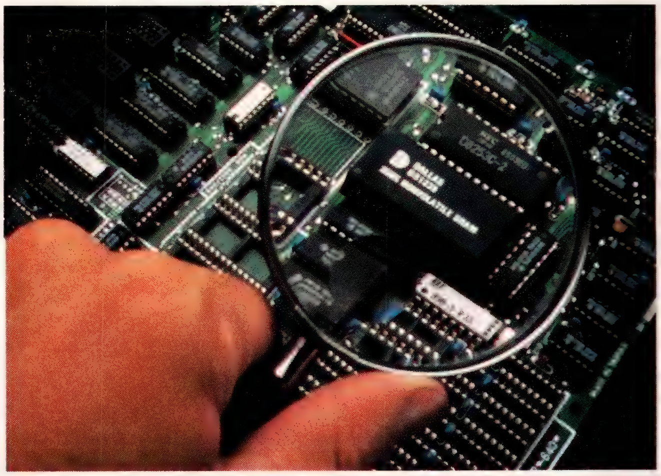


***The 0.8-μm channel length used in this 4k×4-bit static RAM,** the CY7C150 from Cypress Semiconductor Corp, accounts for its 15-nsec access time.*

ic RAM from IDT is the IDT7174, a 35-nsec, 8k×8-bit RAM with an on-chip cache-address comparator, an asynchronous-clear pin, and a high-speed chip-select pin. The IDT7174 costs $95 (100).

Advanced Micro Devices, although far from being a start-up company, committed itself to an agressive schedule of new-product announcements during 1986, and as a result, the company's memory line now includes a number of ASIC chips with special features. The Am9151, for example, is a 1k×4-bit static RAM that offers on-chip diagnostic capability via the proprietary Serial Shadow register. The register's diagnostics break the normal feedback path of a sequential data network and establish a logical path via which the register defines inputs and samples outputs; it's therefore able to detect system- or board-level malfunctions. A 40-nsec version of the Am9151 costs $25 (100).

At least three companies think that the best way to improve CMOS static RAMs is to make them nonvolatile. Dallas Semiconductor markets the DS1235, a 32k×8-bit RAM that retains its memory in the event of a power loss. Powered by an on-chip lithium energy source, this IC has a 200-nsec access time, comes in a standard 28-pin DIP, and costs $42.90 (100). Thomson Components-Mostek Corp added a real-time clock to its 120-nsec, 2k×8-bit battery-backed RAM, the MK48T02/12(B), which sells for $25.83 (100). Catalyst Semiconductor offers a line of nonvolatile CMOS products, including a 200-nsec, 64×4-bit static RAM priced at $5.65 (100) and a 200-nsec, 256×4-bit static RAM that costs $14.87 (100).

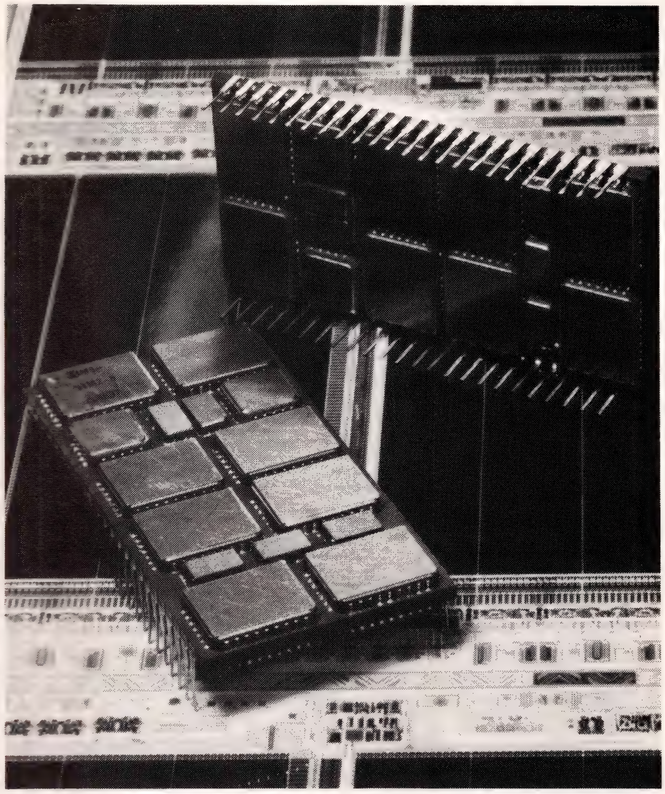


If you need a memory that's nonvolatile, *consider the DS1235 32k×8-bit memory module from Dallas Semiconductor. This 256k-bit RAM features a 200-nsec access time and comes in a standard 28-pin DIP.*

Despite the speed advantages that bipolar technology can offer, as circuits become more densely packed, the problem of handling the heat that bipolar circuits dissipate becomes more acute. As a result, many designers are willing to sacrifice a small amount of performance for a significant decrease in power consumption, and so they're turning to CMOS. Furthermore, designers are building an increasing number of battery-backed systems, which adds to the demand for low-power components.

Fortunately, the performance specs for low-power MOS static RAMs are beginning to compete favorably with bipolar devices. Access time is directly proportional to the feature size in CMOS TTL-compatible static RAMs, and it's therefore increasingly difficult to reduce the access time in increasingly dense TTL memories, but Performance Semiconductor has developed a 256×4-bit static RAM with submicron (0.8 μm) effective channel lengths and a 10-nsec access time. Prices range from $5.45 to $12.77 (100).

Cypress Semiconductor has a 1k×4-bit static RAM, the CY7C150, which uses 0.8-μm channel lengths. It



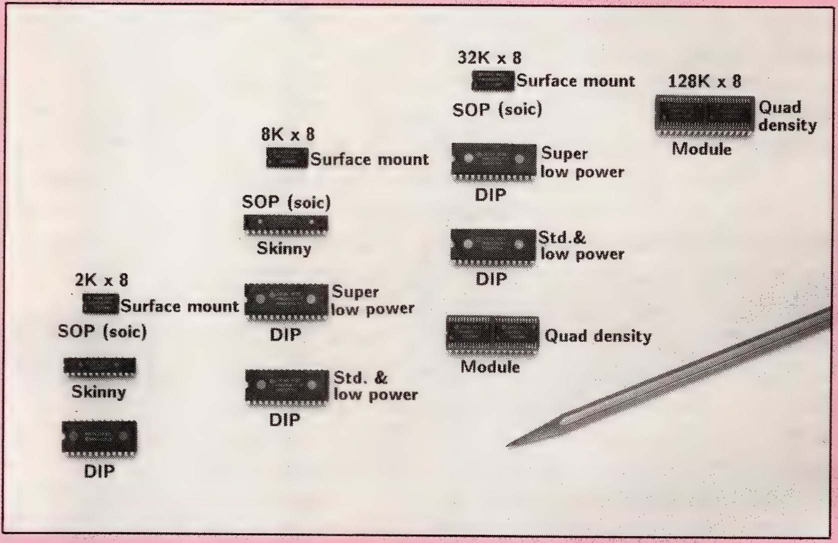
For designs that require 1M bit of reliable static RAM on a DIP, *the HM91M2, a fully buffered memory module from Harris, features 6-T cells for protection against soft errors and radiation.*

Because transistors are more resistant to alpha-particle radiation and temperature variations than resistors, 6-T cells are less susceptible to soft errors than 4-T cells.

specs a 15-nsec access time, and it's 67% faster and has a 50% smaller cell and 33% smaller die than a comparable 1.2-μm static RAM. The CY7C150 is available in either a 24-pin, 300-mil plastic DIP; a 24-pin, 300-mil ceramic DIP; or a 28-pin rectangular LCC. Prices for the part begin at $29.40 (1000).

VLSI Technology, in conjunction with VISIC Inc, has produced a line of 16k-bit static RAMs with 20-nsec access times. The VT20C18 uses 6-T cells for high reliability and low power consumption. Its 2k×8-bit organization makes the VT20C18 suitable for use in cache memory, writable control stores, and data buffers. An automatic power-down feature lets the chip draw just 7 mA in standby mode. A fast-chip-enable option (VT20C19) provides data access in 10 nsec. You can also order this chip in 4k×4-bit organizations, with or without an output-enable control. Both parts cost $21.24 (1000).

Packages shrink as densities increase



***Advances in process technology inspire manufacturers to squeeze more bytes into smaller packages,** as illustrated by the evolution of byte-wide static-RAM packages. Each generation makes its debut in a standard 600-mil DIP, eventually reducing its size to that of a surface-mount package. This year, TAB memories may carry the packaging evolution to even smaller dimensions. (Photo courtesy Hitachi Corp)*

The electronics industry has been steadily packing more device functions into smaller packages—and static RAMs are no exception. Memories have expanded from bit-wide (×1 bit) to byte-wide (×8 bits) organizations, and many are available in ×9 configurations, in which a parity bit is added to the byte-wide pin layout.

Accompanying this increase in memory densities is a package shrinkage driven by a need for increasingly compact circuits. As a result, the number and variety of packages you'll find static RAMs in can be bewildering.

Surface mount vs through hole

You should first differentiate between the surface-mount and the through-hole packages. The most common through-hole type is the dual in-line package (DIP), manufactured in both plastic and ceramic materials. You can order static-RAM DIPs in standard 600-mil-wide packages that have 16 to 64 pins on 100-mil centers.

If you need to conserve board space, you can order your RAMs in a "skinny" 300-mil DIP. For maximum space utilization, try a single in-line package (SIP). Resembling a DIP turned on its side, a SIP can range in width from 100 to 200 mils, with 16 to 42 leads on 100-mil centers.

The surface-mount packages offer more variety—with respect to both style and terminology. Memories with leads that bow outward like gull wings come in two types of plastic package: the small-outline (SO) package, with leads on two sides, arranged in 50-mil centers; and the flat plastic package (FPP), with leads protruding from four sides arranged in 26-, 31-, or 39-mil centers.

Virtues and vices

The SO package offers a number of advantages. It's thin, so it consumes little board space. Its small solder pads let you run wires under the package and between the pads. And like all plastic leaded surface-mount packages, the SO package is self aligning, making it easy to use with automatic mounting and

AMD offers a 4k×4-bit static RAM with a 20-nsec access time. The Am99C58's chip-enable feature automatically reduces power consumption by 70% when the device is in standby mode. Alternatively, you can order the Am00C59, which gives you a chip-select access time of 10 nsec, for use in multiple arrays and cache memories. Available in 24-pin, 300-mil DIPs and 28-pin LCCs, both chips cost $24.75 (100).

If you need a fast 64k-bit memory, consider either the 64k×1-bit SR64K1 or the 16k×4-bit SR64K4 CMOS static RAMs from Lattice Semiconductor. These devices spec 35-nsec access times and come in 22-pin 300-mil DIPs or in LCCs. Pricing begins at $22.26 (100) for the SR64K1, and at $44.72 (100) for the SR64K4.

For even greater speed, you can turn to Motorola's 64k×1-bit MCM6287 and 16k×4-bit MCM6288, which spec access times as low as 25 nsec. The devices are fabricated from a double-metal, double-polysilicon

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soldering equipment. The SO package and FPP both allow easy visual inspection of solder connections, because their gull-winged leads bend away from the package. Those same leads are easily bent, however, and you can run into problems when you're using automatic placement equipment.

Static RAMs with leads shaped in a J bend come in two types of plastic package: a plastic leaded chip carrier (PLCC) and a small-outline J-bend (SOJ) package. The PLCC has 18 to 64 leads divided among four sides on 50-mil centers. SOJ packages sport 20 to 32 leads located on two sides of the package, arranged in 50-mil centers.

These J-bend leads aren't as easily deformed as gull-wing leads, but they tuck under the package, making visual inspection more difficult. These leads also seem to be more appropriate for the infrared (IR) soldering techniques currently in use by Japanese manufacturers than for the vapor-phase soldering equipment that's common in the United States.

As a result, some American designers have faced problems keeping the SMDs from popping off the circuit boards. You must remember to consider carefully the prebake time, the temperature profile curves of your devices, the hydroscopic moisture content of any plastic packages, the expansion coefficient of the die within each package, and the size of the die relative to its package (that is, the aspect ratio).

Leadless chip carriers (LCCs) are also greatly affected by thermal and torque stresses induced by soldering techniques. However, the leadless configuration eliminates lead deformation concerns and results in minimized wiring lengths, thus providing excellent high-frequency characteristics. As a result, designers primarily use this package in military and high-reliability applications. If board space is scarce, you can use these devices to achieve a maximum mounting density.

You'll frequently find ECL RAMs offered as flat-package glass (FPG) devices with 20 or 24 straight leads protruding from either two or four sides of the package, on 50- and 30-mil centers. However, the straight leads found on these packages are easily bent and deformed; either outcome can lead to soldering problems. Still, the package is thin, is more heat resistant than plastic packages, and suits use in harsh environments.

Memory modules offer you maximum density with standard pin configurations. Although monolithic static RAMs have achieved only a maximum density of 256k bits, you can buy a quad-density memory module that gives you 1M bit of memory using a standard 32-pin DIP. With four standard, 256k-bit monolithic memories in SO packages, attached to the top and bottom of a DIP, a module allows you to design with tomorrow's memory densities today. But keep in mind that a module composed of four ICs is statistically less reliable than a single monolithic chip.

The next trend may let you eliminate packages altogether. Tape-automated bonding (TAB) is already available for ECL memories as a way of addressing heat dissipation. The TAB process encases the die in a 35-mm, 8-mil-thick film, yielding unprecedented circuit densities but requiring precise placement and soldering techniques and exacting tolerances.

Recognizing the lengthy development cycles that are common among the established semiconductor firms, a number of US start-ups have rushed into the breach.

CMOS process using 1.5-μm design features. The MCM6287 costs $43.40, and the MCM6288 costs $54.60.

For byte-wide applications, NEC offers an 8k×8-bit CMOS static RAM in a choice of small-outline packages, as well as a standard DIP. The μPD4364 is a 64k-bit byte-wide memory with a 100-nsec access time and an operational power draw at or below 45 mA. The device comes in a 28-pin, 600-mil DIP, a skinny 300-mil DIP, or a "miniflat" 450-mil package. Another part, the μPD4464, is similar to the μPD4364, but it operates over −40 to +85°C and specs a 120-nsec access time. In sample quantities, the μPD4364 costs $8 and the μPD4464 costs $13.

Mitsubishi crams even more bits into a 28-pin DIP with its 32k×8-bit M5M5256 static RAM. Offered in 70- to 150-nsec versions, these chips dissipate 700 mW max. The company achieves this level of performance by using resistive-load NMOS cells and CMOS peripherals. Pricing for the 150-nsec version is $38.50 (100).

Bipolar maintains performance edge

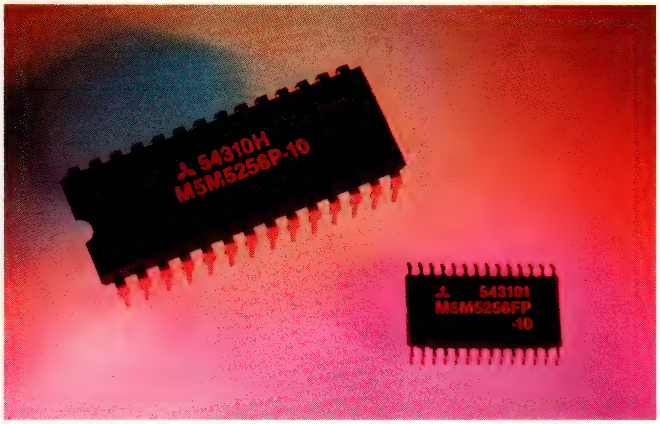
Designing with bipolar memories—as opposed to MOS RAMs—requires special consideration of speed-induced noise problems as well as heat dissipation. Although the electronics industry is focusing a great deal of attention on the use of surface-mount devices (SMDs) to reduce the size, cost, and efficiency of circuits, surface-mount technology does not readily lend itself to the manufacture of bipolar memories. Packing bipolar devices into smaller packages that are more densely arranged only causes increased heat, inductance problems, and noise.

A promising alternative to DIPs and SMDs might come from a practice known as tape-automated bonding (TAB), which will allow manufacturers of bipolar devices to offer designers a practical way to move these components closer together. (For a longer discussion on static-RAM packages, see **box,** "Packages shrink as densities increase.") NEC, a company that has been manufacturing ECL TAB parts for internal use over the past two years, is willing to field inquiries about both ECL and MOS TAB memories, but it isn't prepared to announce the commercial availability of these devices. Fujitsu, on the other hand, plans to introduce a line of ECL TAB static RAMs in the first quarter of 1987.

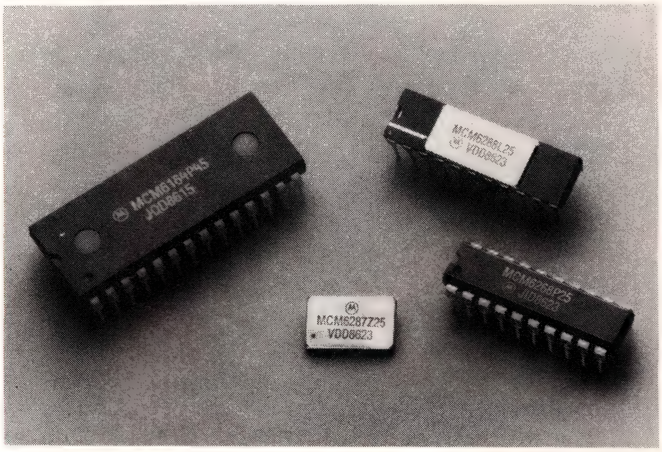
Fujitsu and Hitachi commanded 80% of the $150 million ECL static-RAM market in 1986. Like the market for dynamic RAMs, that of ECL static RAMs consists primarily of commodity chips with few differentiating features. However, the wealth of experience enjoyed by these two IC giants has produced some interesting solutions to the problems involved in ECL design.

For example, Fujitsu offers a line of SMD static RAMs called "flip chips," which feature a die mounted on the top of each package for better cooling. One example, Fujitsu's MB7703H-5CF, offers a 256×16-bit organization with a 5-nsec access time. To dissipate the 4½W it consumes, this device actually incorporates a cooling tower in its 60-pin gull-wing flat pack. Prices range from $75 to $100 (OEM qty).

As speed decreases, so does power consumption. Fujitsu's 4k×4-bit MBM10484A-10C consumes 1.35W and specs a 10-nsec access time. Available in a DIP, LCC, or flat pack, this device costs $47 (1000).



Offering a range of access times from 150 to 100 nsec, *Mitsubishi's byte-wide, 256k-bit M5M5256 CMOS static RAMs combine high density with 700 mW of power dissipation.*



Available in an assortment of packages, *Motorola's family of 25-nsec CMOS static RAMs come in 16k- and 64k-bit versions.*

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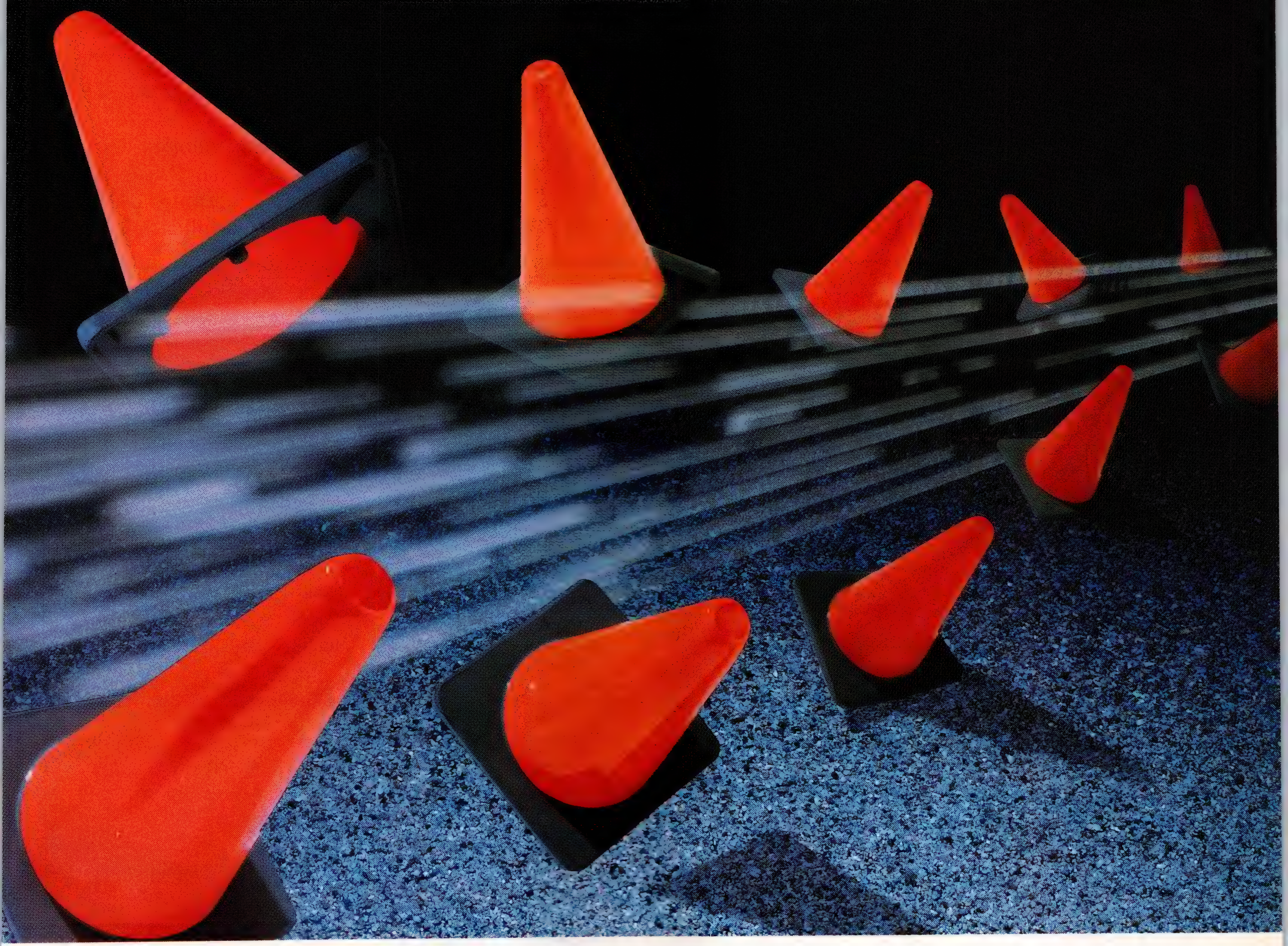

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Part No.	Speed	Type
WS57C191/291	40 ns.	2k x 8 CMOS RPROM
WS57C43	55 ns.	4k x 8 CMOS RPROM
WS57C49	55 ns.	8k x 8 CMOS RPROM
WS57C64F	55 ns.	8k X 8 CMOS EPROM
WS57C128F	70 ns.	16k x 8 CMOS EPROM
WS57C256F	70 ns.	32k x 8 CMOS EPROM
WS57C65	55 ns.	4k x 16 CMOS EPROM
WS57C257	70 ns.	16k x 16 CMOS EPROM

WaferScale
INTEGRATION, INC.

CIRCLE NO 105

Several companies think that the best way to improve CMOS static RAMs is to make them nonvolatile.

Noteworthy among Hitachi's larger ECL memories are two 64k-bit static RAMs. The 64k×1-bit HM6787 features a 20-nsec access time, while the 16k×4-bit HM6788 allows access in 25 nsec. The HM6787 consumes 180 mW during operation (35 mW in standby) and costs $20 (OEM qty). The HM6788 consumes 230 mW during operation (10 mW in standby) and sells for $17.50 (OEM qty).

AMD's 10/100480 16k×1-bit ECL memory consumes 1.2W and offers a 15-nsec access time. Prices start at $41.75 (100) for parts in 20-pin ceramic DIPs. For sophisticated drive and interface applications, AMD

Manufacturers of static RAMs

For more information on static RAMs, contact the following manufacturers directly or circle the appropriate numbers on the Information Retrieval Service card.

Advanced Micro Devices Inc
Box 3453
Sunnyvale, CA 94088
(408) 732-2400
Circle No 667

Alliance Semiconductor
1930 Zanker Rd
San Jose, CA 95112
(408) 436-1860
Circle No 668

AT&T Technology Systems
1 Oak Way
Room #2WC106
Berkeley Heights, NJ 07922
(800) 372-2447
Circle No 669

Catalyst Semiconductor Inc
4051 Burton Dr
Santa Clara, CA 95054
(408) 980-9144
Circle No 670

Cypress Semiconductor Corp
3901 N 1st St
San Jose, CA 95134
(408) 943-2600
Circle No 671

Dallas Semiconductor Corp
4350 Beltwood Parkway S
Dallas, TX 75244
(214) 450-0400
Circle No 672

Dense-Pac Microsystems Inc
7321 Lincoln Way
Garden Grove, CA 92641
(714) 898-0007
Circle No 673

Electronic Designs Inc
35 South St
Hopkinton, MA 01748
(617) 435-9077
Circle No 674

Fairchild Semiconductor
33 Healdsburg Ave
Healdsburg, CA 95448
(206) 841-6621
Circle No 675

Fujitsu Microelectronics Inc
3320 Scott Blvd
Santa Clara, CA 95054
(408) 727-1700
Circle No 676

Harris Semiconductor Corp
Box 883
Melbourne, FL 32901
(305) 724-7800
Circle No 677

Hitachi America Ltd
2210 O'Toole Ave
San Jose, CA 95131
(408) 942-1500
Circle No 678

Inmos Corp
Box 16000
Colorado Springs, CO 80935
(303) 630-4000
Circle No 679

Inova
1400 Dell Ave
Campbell, CA 95008
(408) 378-3000
Circle No 680

Integrated Device Technology Inc
Box 58015
Santa Clara, CA 95052
(408) 727-6116
Circle No 681

Intel Corp
151 Blue Ravine Rd
Folsom, CA 95630
(916) 351-2740
Circle No 682

Lattice Semiconductor Corp
15400 NW Greenbrier Pkwy
Beaverton, OR 97006
(503) 629-2131
Circle No 683

Matra-Harris
2840-100 San Tomas Expressway
Santa Clara, CA 95051
(408) 986-9000
Circle No 684

Micron Technology Inc
2805 E Columbia Rd
Boise, ID 83706
(208) 386-3900
Circle No 685

Mitsubishi Electronics
1050 E Arques Ave
Sunnyvale, CA 94086
(408) 730-5900
Circle No 686

Mosel Corp
491 Macara Ave
Suite 1004
Sunnyvale, CA 94086
(408) 733-4556
Circle No 687

Motorola Inc
MOS Memory Products Group
Box 6000
Austin, TX 78762
(512) 928-6711
Circle No 688

NEC Electronics Inc
Box 7241
Mountain View, CA 94039
(415) 960-6000
Circle No 689

Oki Semiconductor Corp
650 N Mary Ave
Sunnyvale, CA 94086
(408) 720-1900
Circle No 690

Panasonic Industrial Co
One Panasonic Way
Secaucus, NJ 07094
(201) 348-5200
Circle No 691

Performance Semiconductor Corp
610 E Weddell Dr
Sunnyvale, CA 94089
(408) 734-8200
Circle No 692

Samsung Semiconductor Inc
5150 Great America Pkwy
Santa Clara, CA 95054
(800) 423-8624
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Iselin, NJ 08830
(201) 321-4597
Circle No 695

Texas Instruments Inc
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Houston, TX 77001
(800) 232-3200
Circle No 696

Thomson Components-Mostek Corp
1310 Electronics Dr
Carrollton, TX 75006
(214) 466-7220
Circle No 697

Toshiba America Inc
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Tustin, CA 92680
(714) 832-6300
Circle No 698

Vitelic Corp
4701 Patrick Henry Dr
Suite 1301
Santa Clara, CA 95054
(408) 727-7256
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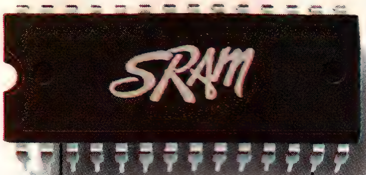
VLSI Technology Inc
1109 McKay Dr
San Jose, CA 95131
(408) 942-1810
Circle No 700

The Mitsubishi 256K *Mixed-MOS SRAM*



Mitsubishi Offers Fast Access For Large Memories.

Fast SRAM Product Selection Guide

Part No.	Organization	Access Time 25 ns	35 ns	45 ns	55 ns	70 ns	85 ns	100 ns	120 ns	150 ns	Package Types Plastic DIP	Leadless Chip Carrier	Small Outline Package
M5M21C67	16K x 1		•	•	•						• 20 PIN	•	
M5M21C68	4K x 4		•	•	•						• 20 PIN	•	
M5M5165	8K x 8					•		•	•	•	• 28 PIN		• 28 PIN
M5M5178*	8K x 8			•	•						• 28 PIN (300 mil wide & 600 mil wide)		• 28 PIN
M5M5179*	8K x 9			•	•						• 28 PIN (300 mil wide only)		• 28 PIN
M5M5187	64K x 1	•*	•*	•	•						• 22 PIN	•	
M5M5188**	16K x 4	•*	•*	•	•						• 22 PIN	•	
M5M5256	32K x 8					•*	•*	•	•	•	• 28 PIN		• 28 PIN

*New product offering, subject to availability.

**Also available in 24 pin version with output enable ($\overline{OE}$) function.

Tomorrow's systems require ever-increasing performance from cache, control store, buffer and program memory.

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You can optimize board layout with Mitsubishi's 32K x 8 organization in both 28 pin DIP and small outline packages. Additionally, 64K x 1 and 16K x 4 organizations are available in 22 pin DIP (300 mil) or leadless chip carriers.

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ELECTRONICS

CIRCLE NO 103

Despite the speed advantages offered by bipolar technology, as circuits become more densely packed, the problem of heat dissipation increases.

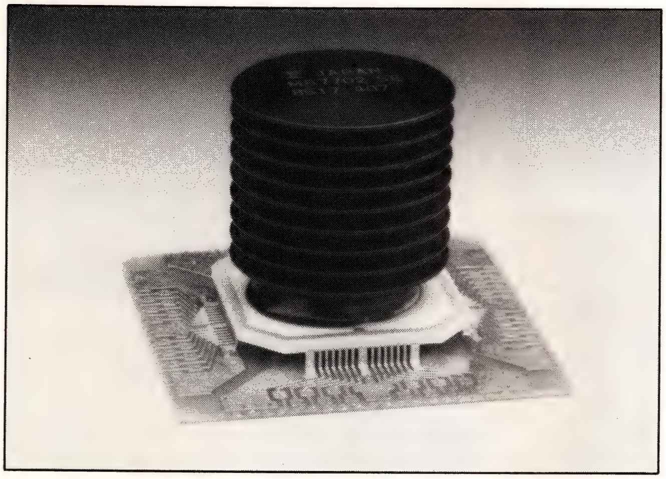
also sells a line of bipolar TTL static RAMs with prices ranging from \$3 to \$25 and organizations varying from 256×1 bits to 512×9 bits. Memories featuring a ×9 organization include a parity bit for error detection.

BiMOS combines process technologies

Several companies are investigating ways to avoid the tradeoffs associated with bipolar and CMOS by integrating both technologies into one wafer fabrication process, which is generally called BiCMOS. This technology combines bipolar's high speed, high drive current, and ECL/TTL-compatibility with CMOS's low power, high complexity, and resistance to soft errors.

Executing a BiCMOS process in a wafer fabrication can involve as many as 26 masking steps—14 steps for the bipolar process and 12 for the CMOS. And 26 masking steps make production too unwieldy, boosting costs and slashing yields. However, one company—Saratoga Semiconductor—has figured out a way to produce a BiCMOS wafer in only 16 masking steps. Saratoga's proprietary self-aligned BiCMOS (SABiC II) process is the basis for this start-up's entire product line, which consists of pin-compatible replacements for both bipolar ECL and CMOS TTL static RAMs. The company's first products, introduced last August, include four 4k-bit ECL static RAMs. Each specs a 15-nsec access time, and all parts range in price from \$14.55 to \$19.55 (100).

Eventually, a process such as BiCMOS may allow static RAM manufacturers to attain 1M-bit densities, but current high-density monolithic static RAMs offer a maximum storage capacity of 256k bits. The more complex circuitry that static RAM cells contain put static RAMs one generation behind dynamic-RAM capacities. But manufacturers continue to search for ways to shrink IC geometries, improve lithography techniques, and increase chip density.



***The cooling tower on this 512×8-bit static RAM,** the MB7700-5 "flip chip" from Fujitsu, helps dissipate the 3.6W generated by the memory. The part specs a 5-nsec access time. A 10-nsec version consumes 3.0W.*

Toshiba offers a 70-nsec CMOS static RAM in a 32k×8-bit organization with an 85-nsec access time. Named the TC55257P, this memory includes a chip-enable power-down feature for low standby power consumption. The TC55257P comes in a 28-pin DIP and costs \$35 (1000).

If you really must get 1M bits of memory in a single package, multichip memory modules offer a practical solution. More reliable than hybrids, modules are easy to repair because each chip is individually, hermetically sealed once it's soldered to the ceramic substrate of the DIP. Consequently, if one RAM IC should fail, you can remove it and replace it with a functional one.

Dense-Pac Microsystems provides an extensive line of static-RAM modules suitable for use in military, aerospace, and commercial applications. The DPS41288 packs 128k×8 bits of CMOS static RAM onto a 600-mil, 32-pin module. This 1M-bit memory features a 100-nsec access time and costs \$240 (100).

Yet another 1M-bit static RAM module offers military-grade reliability. The HM91M2 from Harris Corp is a fully buffered CMOS product that uses sixteen 6-T 8k×8-bit monolithic RAMs, two CMOS octal buffers, and two 3:8 decoders. Packaged in LCCs, these 20 ICs mount on a multilayered ceramic substrate to form a 2.66×1.3-in., 48-pin module with standard 100-mil centers between pins. The 6-T RAMs use little standby current, and they protect the module against soft errors and radiation. The HM91M2 has an access time of 180 nsec. Price range is \$2600 to \$2900 (100). **EDN**

References

1. Leibson, Steven, "Surface-Mount Technology," *EDN*, October 2, 1986, pg 134.

2. *Surface Mount Package User's Manual*, Hitachi publication #M15, August, 1986.

3. Wright, Maury, "Process improvements and special features reduce high-end static-RAM access times," *EDN*, April 17, 1986, pg 57.

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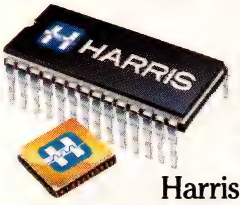

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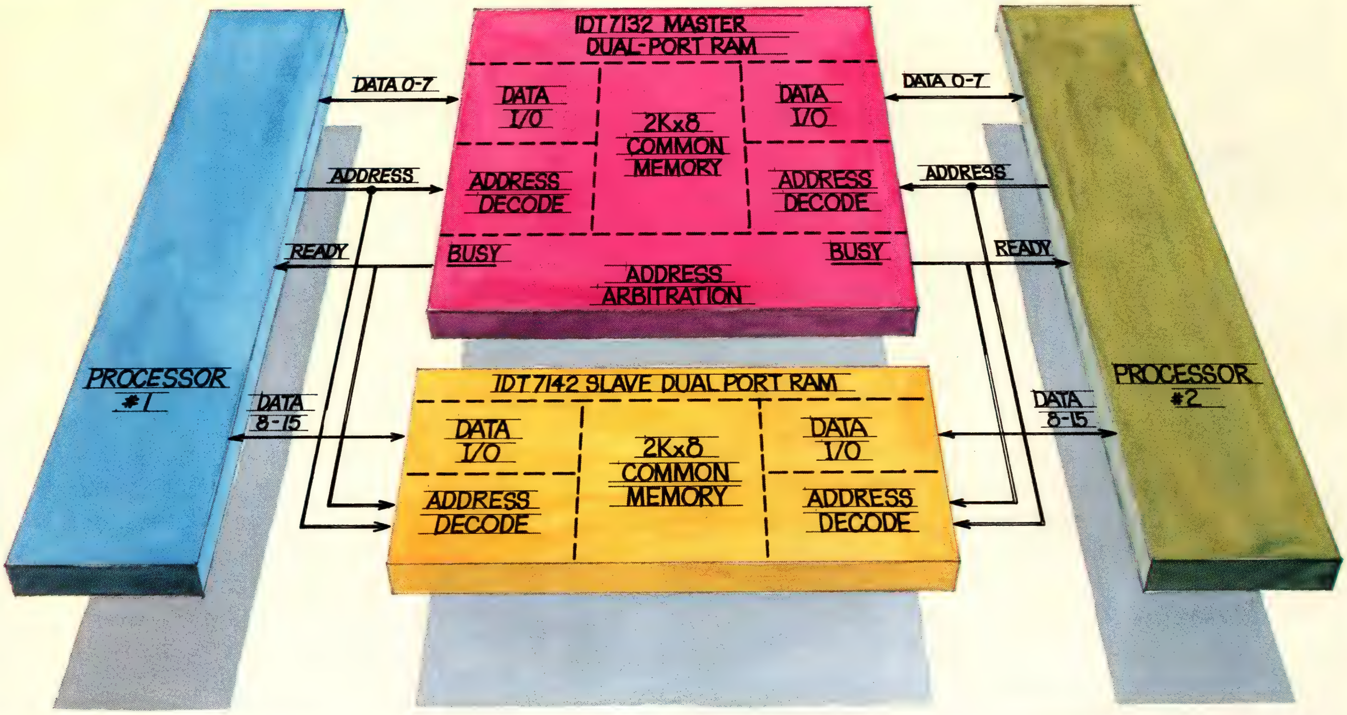

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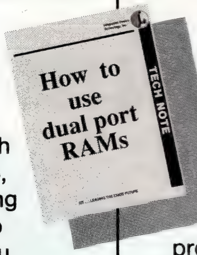

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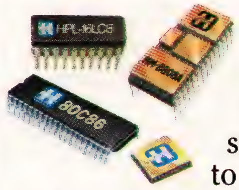

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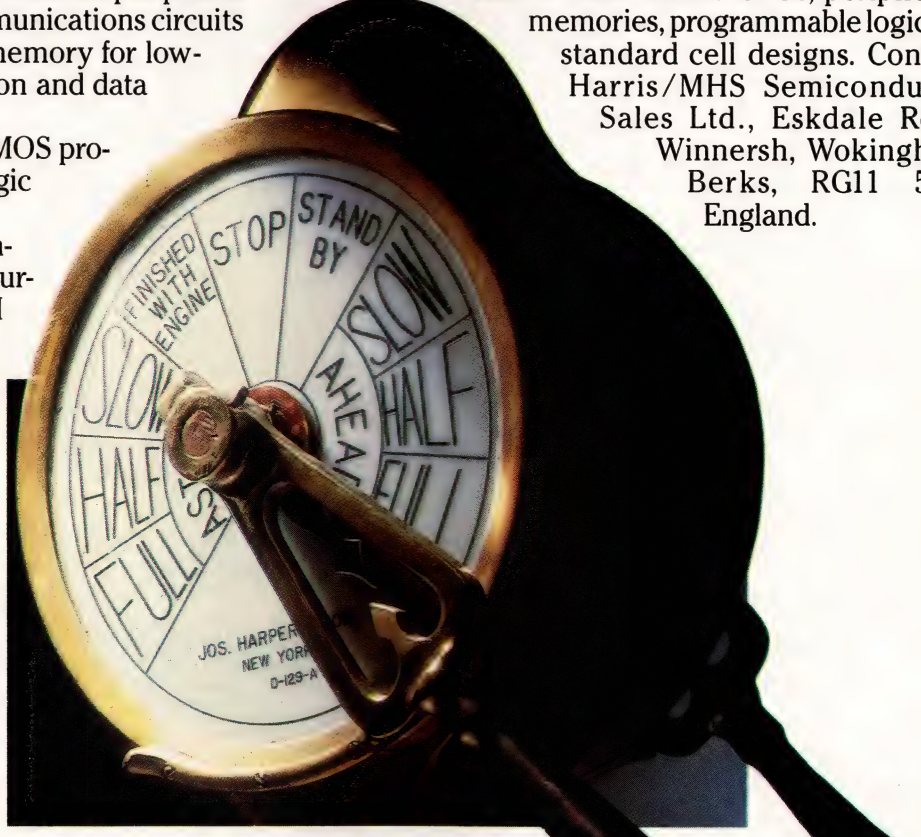

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CIRCLE NO 106

Use statistics to test communications systems efficiently

Unless you use statistics, it's virtually impossible to determine just how many measurements are required for an accurate test of a system like a telecommunications receiver. In fact, you're probably testing your systems more than you have to.

R F Cobb, *Harris Corp*

If you're designing a system such as a radar receiver that has a statistical spec (probability of detection, false-alarm rate, bit-error rate, or mean time between failures), you can't test the system exactly. To determine a radar receiver's exact hit rate, for example, you'd have to test the apparatus forever. Fortunately, if you run it through just enough trials, you can predict a hit rate that closely approximates the exact hit rate. If you merely need to know whether or not the radar receiver meets a minimum specification, even fewer trials are necessary.

To test a statistical characteristic, you must know how many tests you should perform. If your radar receiver specs a probability of detection of 0.99, you have a choice of defining the acceptance criterion as 99 hits in 100 trials, 990 hits in 1000 trials—or as something else. Only by using statistics can you determine the minimum number of trials that will adequately test your system.

Before you can appraise your testing procedures, though, you must master the basic concepts of statistics applicable to system testing. If you're well-versed in this area of statistics, you might want to skip directly to page 148.

The number you are seeking is the number of trials you need to measure the true value of the mean of your samples with acceptable accuracy. The expected value of K samples is

$$E[X] = \frac{1}{K}\sum_{i=1}^{K} X_i,$$

where X_i are the values that you measure. If you measure N samples, the mean (μ) of the samples is

$$\mu = \frac{1}{N}\sum_{i=1}^{N} X_i.$$

You can use the variance of your measurements to determine how close your measured mean is to the true mean of your sample. The variance (σ^2) of a sample is the average value of the square of its deviation from the mean:

$$\sigma^2 = E[(X - \mu)^2]. \tag{1}$$

By using the expansion properties of E[X] (where A is a constant),

$$E[X + Y] = E[X] + E[Y]$$
$$E[AX] = AE[X],$$

and expanding the square in **Eq 1,** you can express the variance as

$$\sigma^2 = E[X^2 - 2\mu X + \mu^2] = E[X^2] - 2\mu E[X] + E[\mu^2]$$
$$= E[X^2] - 2\mu^2 + \mu^2$$

$$\sigma^2 = E[X^2] - \mu^2.$$

You can express the variance of a population of N elements as

$$\sigma^2 = \frac{1}{N}\sum_{i=1}^{N} X_i^2 - \left[\frac{1}{N}\sum_{i=1}^{N} X_i\right]^2. \tag{2}$$

These equations are exact for finite sample populations, but unfortunately systems that have statistical specs don't have finite sample populations: You can always perform another test on such a system. The only way you can estimate the mean and variance of your system is to test a finite number of samples.

To analyze a population of n samples, you must estimate your parameters. The estimate of the mean, m, of n independent samples is

$$m = \frac{1}{n}\sum_{i=1}^{n} X_i.$$

This expression doesn't tell you how accurate the estimate is. To get a feel for the accuracy of the estimate, you can apply the following theorem (**Ref 1**):

$$\sigma_\mu^2 = \frac{\sigma^2}{n}, \tag{3}$$

where σ_μ^2 is the variance of the estimate m of the true mean μ. The smaller σ_μ^2 is, the better the estimate.

Sometimes you know the value of the variance of the sample population, σ^2. For example, radar receivers often use an automatic gain control that keeps σ^2 (the noise power) constant. When you know σ^2, you can estimate the mean of the detector output and decide whether your system has detected a signal. The mean is higher when signal and noise both are present than when noise alone is present. Often, however, you don't know the variance, so you must estimate it. If you know the value of μ for the population you're testing, then you can use **Eq 2** to calculate the variance.

If you don't know μ (and you usually don't), you must estimate it to calculate the variance. The estimate of the variance, s^2, is

$$s^2 = \frac{1}{n-1}\sum_{i=1}^{n} (X_i - m)^2.$$

By expanding the square, you can express the unbiased estimator of the variance as

$$s^2 = \left(\frac{1}{n-1}\right)\left[\sum_{i=1}^{n} X_i^2 - \frac{1}{n}\left(\sum_{i=1}^{n} X_i\right)^2\right]. \tag{4}$$

A word of caution is appropriate at this point: Make certain that your measurements are independent. The

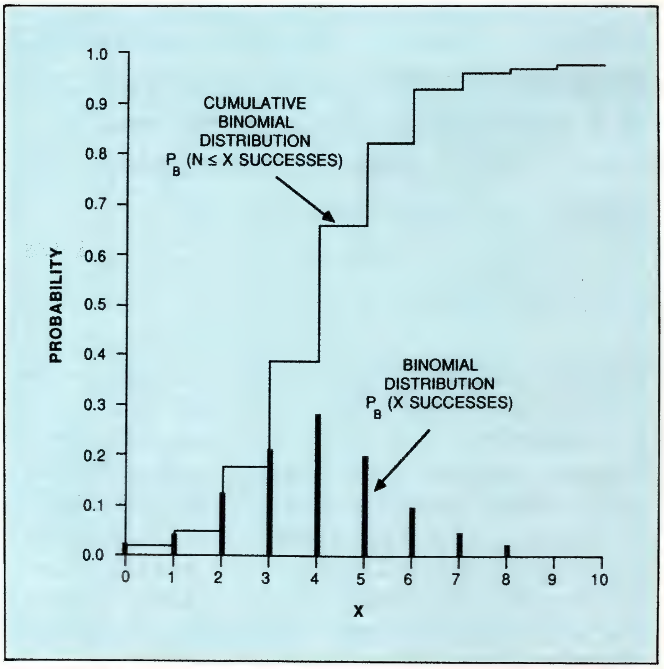

***Fig 1—The binomial distribution gives** the probability of X successes in N trials. The cumulative binomial distribution gives the probability of as many as X successes in N trials. The above graph results when N=10 and when the probability of success in one trial is 0.4.*

If your system has a probability-detection spec of 0.99, you have a choice of how to define it.

simple statistical analysis presented here isn't meaningful if the outcome of any trial depends on a previous trial. Nonetheless, dependent trials are quite common.

For example, if you're testing detection probability by sending a series of signal pulses and you space the pulses too closely—so closely that filter transient ringing doesn't have time to die out—then you're making dependent measurements. Another example of a dependent measurement is the bit-error probability at the output of a receiver with a decoder. The errors often occur in bursts and therefore aren't independent events.

Two probability distributions are key

If your trials are independent, you'll be able to plot your results in a bell-shaped curve. These results, which are probability distributions, usually fit into binomial or Gaussian distributions. Tests that can have only two results—pass or fail—fit the binomial distribution, $P_B(X)$:

$$P_B(X) = {}_NC_X\, p^X q^{N-X}. \tag{5}$$

Eq 5 is the probability that X successes will occur in N trials. The letter p represents the probability of a pass, q represents the probability of failure ($q=1-p$), and ${}_NC_X$ represents the binomial coefficient:

$${}_NC_X = \frac{N!}{X!(N-X)!}.$$

If you're testing a radar receiver whose detection probability p for a given S/N ratio is 0.9, then $q=0.1$. The probability of $X=9$ successes in $N=10$ trials is

$$P_B(9) = {}_{10}C_9\,(0.9)^9\,(0.1)^1 = 0.3874.$$

The cumulative binomial distribution gives the probability of achieving n hits in N trials:

$$P_B(X \le N) = \sum_{i=0}^{N} {}_NC_i\, p^i q^{N-i}.$$

The probability of achieving more than A but fewer than B hits in N trials is

$$P_B(A \le X \le B) = \sum_{i=A}^{B} {}_NC_i\, p^i q^{N-i}.$$

For the radar receiver with the detection probability of 0.9, the probability of 7 to 9 hits in 10 trials is

$$P_B(7 \le X \le 9) = 0.0574 + 0.1937 + 0.3874 = 0.6385.$$

Fig 1 plots the binomial distribution and the cumulative binomial distribution. In this graph, $N=10$ and $p=0.4$. Once you know the values of N and p, you can use the binomial distribution to analyze your test results. For a binomial distribution, the mean and variance are

$$\mu = Np$$
$$\sigma^2 = Npq = Np(1-p).$$

In **Fig 1**, the mean is 4, and the variance is 2.4.

Use recursive techniques

For small values of N, you can calculate the binomial coefficient directly from **Eq 5.** But if N is too large, you won't be able to calculate N!. For example, 69! is

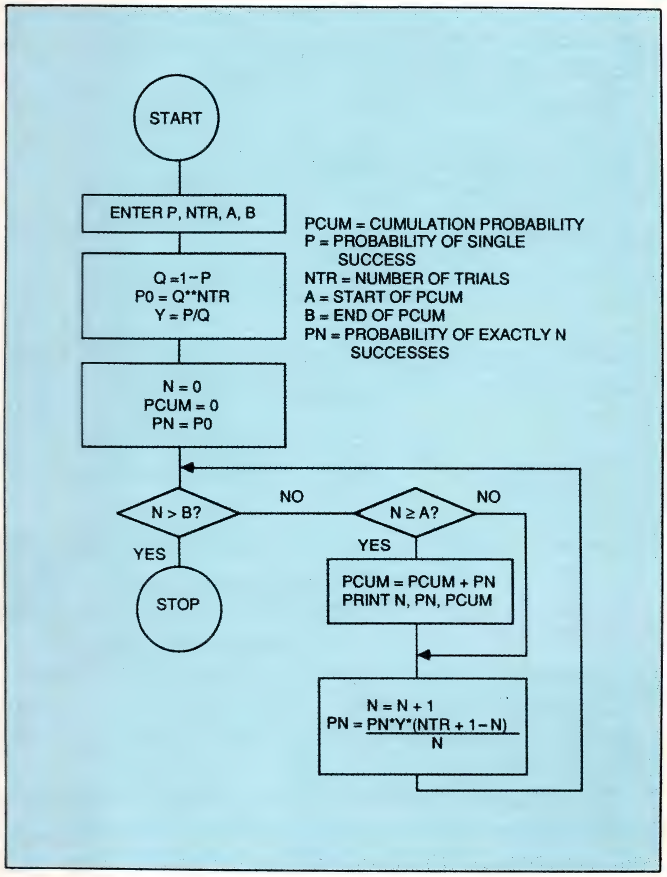

Fig 2—By translating this flow chart *into a computer program, you can calculate the binomial and cumulative binomial distributions.*

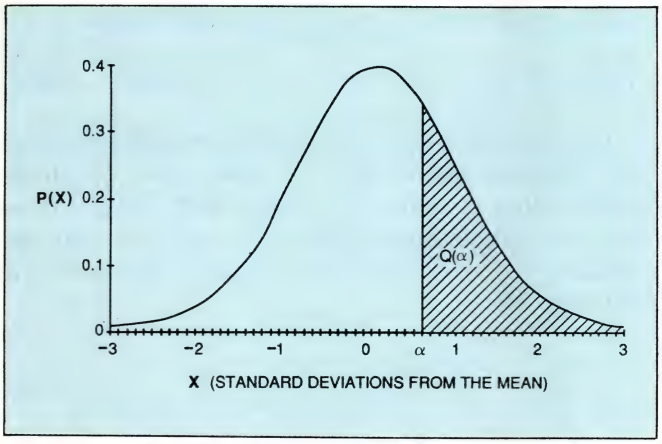

Fig 3—For this Gaussian distribution, the area under the curve between any two numbers on the x-axis is the probability that the result of a test lies within that range.

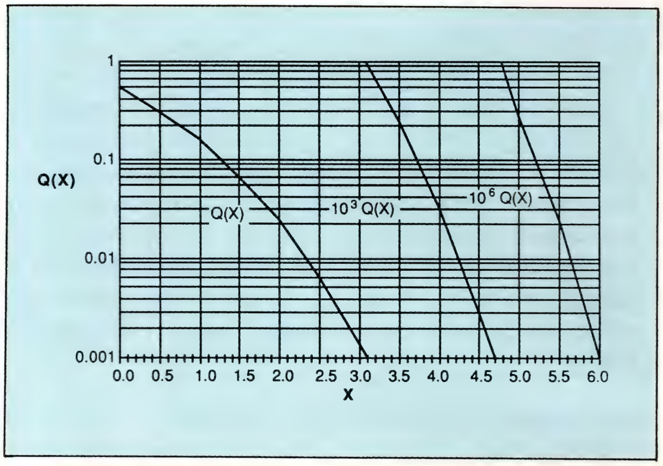

Fig 4—Looking at this graph, you can see that Q(X) changes steeply when X>3.

1.711×10^{98}, which is about as large a number as most handheld computers can calculate accurately.

Eq 5 is the quotient of two factorials, so the binomial coefficient can be a small number even when the factorials are enormous. By using recursion techniques, you can calculate the binomial coefficient.

You can express ${}_NC_X$ as

$$ {}_NC_X = \frac{N!(N-X+1)!}{X(X-1)!\,(N-X+1)!} $$

$$ = \left(\frac{N-X+1}{X}\right)({}_NC_{X-1}). $$

You also know that $p^X=pp^{X-1}$ and $q^{N-X}=(q^{N-x+1})/q$. Using these recursion formulas in **Eq 5** gives

$$ P_B(X) = \frac{N-X+1}{X}\left(\frac{p}{q}\right)P_B(X-1). \qquad \textbf{(6)} $$

By evaluating **Eq 5** for X=0, you can determine that $P_B(0)=q^N$. To calculate $p_B(X)$, you calculate q^N and then use **Eq 6** to work your way in ascending order to any value of X. You can find the cumulative binomial distribution simply by saving each intermediate p_B value.

The flow chart in **Fig 2** documents this recursion process. The algorithm works well, unless q^N is too small for your machine's range.

The binomial distribution describes the outcomes of tests having only two possible results. However, many measurements have an infinite number of possible outcomes (for instance, the measurement of noise voltage). The results of multiple trials of such measurements fit the Gaussian distribution. In a set of N trials from a binomial population, the possible outcomes are zero successes, one success, and so on to N successes. The probability of a noninteger number of successes, a negative number of successes, or a number of successes greater than N is zero. The Gaussian distribution, however, is continuous. Any finite range of values has some nonzero probability of happening.

If you perform a large number of tests on a binomial population, however, the resulting distribution begins to look Gaussian. For example, if N=10,000, then the integers are so closely spaced relative to N that the distribution begins to look continuous. The advantage of using a Gaussian distribution rather than a binomial one to model your testing is that you can make calculations more easily on the continuous Gaussian distribution than on the binomial one.

After a closer look at the Gaussian distribution, you'll see how to use it to approximate the binomial distribution. The Gaussian distribution (P_G) is

$$ P_G(Y) = \frac{1}{\sqrt{2\pi}\,\sigma}\exp\left(-\frac{(Y-\mu)^2}{2\sigma^2}\right). $$

The cumulative Gaussian distribution is an integral of the Gaussian distribution:

$$ P_G(Y \le X) = \int_{-\infty}^{X} P_G(Y)dY. $$

You rarely use the cumulative Gaussian distribution. The Q function,

$$ Q(X) = P_G(Y > X) = 1 - P_G(Y \le X) = \int_{X}^{\infty} P_G(Y)dY, $$

A word of caution: Make certain that your measurements are independent. Dependent measurements occur more often than you might suspect.

which describes the probability that Y will fall above the threshold value X, is more common. **Fig 3** plots the Gaussian distribution and the Q function.

The mean (μ) and the variance (σ^2) have the same meanings for the Gaussian and the binomial distributions. However, the definitions of the mean and the variance are quite different for Gaussian and for binomial distributions. For a Gaussian distribution, the mean is

$$\mu = \int_{-\infty}^{\infty} YP_G(Y)dY.$$

The definition of the Q function assumes that $\mu=0$ and $\sigma=1$. If you need to know Q for a variable for which $\mu\neq 0$, $\sigma\neq 1$, or both, you can normalize the Q function by calculating $\alpha=(X-\mu)/\sigma$. You can then look up $Q(\alpha)$ in a table of Q functions.

Use a polynomial approximation for Q(X)

You can't calculate Q(X) exactly, but you can approximate it. The approximation of Q(X) is

$$X \geq 0$$
$$Q(X) = Z(X)\,(B_1T + B_2T^2 + B_3T^3 + B_4T^4 + B_5T^5)$$

$$X < 0$$
$$Q(X) = 1 - Z(X)\,(B_1T + B_2T^2 + B_3T^3 + B_4T^4 + B_5T^5),$$

where

$$Z(X) = \frac{1}{\sqrt{2\pi}}\exp\left(-\frac{X^2}{2}\right)$$
$$T = \frac{1}{1+px}$$
$$p = 0.2316419$$
$$B_1 = 0.319381530$$
$$B_2 = -0.356563782$$
$$B_3 = 1.781477937$$
$$B_4 = -1.821255978$$
$$B_5 = 1.330274429.$$

This approximation (**Ref 2,** Formula 26.2.17) is accurate to within $\pm 10^{-7}$. **Fig 4** shows why this level of accuracy is adequate. The Q function is so steep for X>3 that even a miniscule error in X causes a large error in Q. Because such a small error in X can cause such a large error in Q, you can't ever know Q accurately enough to care about a 10^{-7} error.

To analyze statistical tests, you need to know both the Q function and $Q^{-1}(Y)$, the inverse Q function. $Q^{-1}(Y)$ gives the value of X for which $Y=Q(X)$. The approximation of $Q^{-1}(Y)$ (**Ref 2,** Formula 26.2.23) is

$$X \leq 0.5$$
$$Q^{-1}(Y) = R - \frac{C_0 + C_1R + C_2R^2}{1 + D_1R + D_2R^2 + D_3R^3}$$

$$X > 0.5$$
$$Q^{-1}(Y) = \frac{C_0 + C_1R + C_2R^2}{1 + D_1R + D_2R^2 + D_3R^3} - R.$$

where

$$R = \left[\ln\left(\frac{1}{X^2}\right)\right]^{1/2} \qquad X \leq 0.5$$
$$R = \left\{\ln\left[\frac{1}{(1-X)^2}\right]\right\}^{1/2} \qquad X > 0.5$$
$$C_0 = 2.515517$$
$$C_1 = 0.802853$$
$$C_2 = 0.010328$$
$$D_1 = 1.432788$$
$$D_2 = 0.189269$$
$$D_3 = 0.001308.$$

You can use the Q function to approximate the

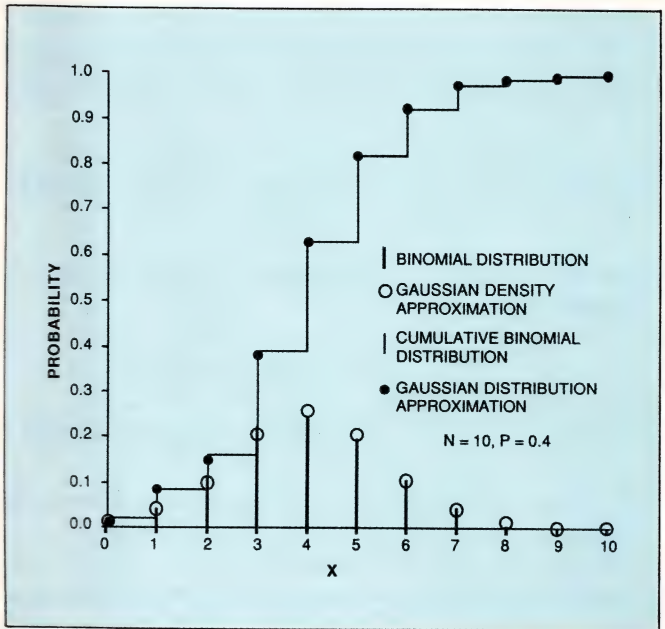

***Fig 5—The Gaussian distribution and the cumulative Gaussian distribution approximate** the binomial distribution and cumulative binomial distribution, respectively. The approximation works best when Npq>3, but in this plot Npq=2.4, and the approximation is good.*

binomial distribution. **Eq 6** gives the binomial distribution over a wide range of numbers, but the equation fails when q^N approaches zero. When q^N approaches zero, the Q function can approximate the binomial distribution.

As **Fig 1** shows, the binomial distribution has a roughly Gaussian shape. In fact, if you plot a Gaussian curve that has $\mu=Np=4$ and $\sigma=\sqrt{(Npq)}=1.549$, you can overlap the binomial distribution (**Fig 5**). The binomial distribution exists only for positive integers; the Gaussian curve continues below zero. But if μ is large relative to σ, the Gaussian curve approaches zero below $x=0$.

You can also match the cumulative distributions, but you must modify the cumulative binomial distribution:

$$P_B(A \le X \le B) \approx Q\left(\frac{A-\mu-0.5}{\sigma}\right) - Q\left(\frac{B-\mu+0.5}{\sigma}\right), \qquad \textbf{(7)}$$

where μ and σ have the same definitions that you've been using (**Refs 3** and **4**). You subtract and add 0.5 because you're using a continuous function to approximate a discrete sum of integers. To approximate a sum of integers, you must center your integral over the integers.

You can test the accuracy of this expression by comparing the exact cumulative binomial distribution,

$$\begin{aligned} P_B\,(2 \le X \le 4) &= P_B(2) + P_B(3) + P_B(4) \\ &= 0.1209 + 0.2150 + 0.2508 \\ &= 0.5867, \end{aligned}$$

and the Gaussian approximation for the cumulative binomial distribution,

$$\begin{aligned} P_B\,(2 \le X \le 4) &= Q\left(\frac{-2.5}{\sigma}\right) - Q\left(\frac{0.5}{\sigma}\right) \\ &= 0.9467 - 0.3734 = 0.5733. \end{aligned}$$

The approximation differs from the exact expression by 2.3%.

The accuracy of the Gaussian approximation for the binomial probability varies. If $p \approx 0.5$, the approximation is good because the binomial distribution matches the Gaussian curve. If p is near 0 or 1, the binomial distribution is skewed. When p is close to 0 or 1, a binomial distribution can look like a Gaussian distribution only if σ is much smaller than μ.

To evaluate the accuracy of the approximation, calculate $\mu=Np$ and $\sigma=\sqrt{(Npq)}$ (**Ref 5**). If the interval $\mu \pm 2\sigma$ lies between 0 and N, then the Gaussian approximation for $P_B(N)$ will be reasonably accurate.

Statistics aid in part estimation, testing

Once you're comfortable with the basic concepts of statistics necessary for testing systems, you can begin your appraisal. First, you must define the objective of your test. Tests can have either of two purposes: measuring a parameter or evaluating a part. When you measure a statistical parameter, you must perform enough tests to feel confident that your measured parameter is close to the true parameter. When you evaluate a part, you need to perform only enough tests to decide whether or not to pass the part.

In the language of statistics, measuring a parameter is called estimation, and evaluating a part is called hypothesis testing. Estimation uses the results of a number of trials to predict the value of a parameter (such as detection probability). In hypothesis testing, a smaller number of tests usually suffices to ascertain whether a batch or a system is acceptable.

Estimation and hypothesis testing are similar in that they both measure a mean, a variance, or both. As an example of estimation, suppose that you want to estimate the mean of a signal that is constant but is masked by noise that has a Gaussian probability distribution. Assume that $\sigma^2=61.0$. You measure 61 independent samples and find that the mean of the samples is 20.

Next, you must evaluate the accuracy of your result. To measure the accuracy of a statistical test, you establish a confidence interval, which is the probability that an estimate is within a certain percentage of its true value. So, if the mean is 20, you can calculate the probability that the sample mean is within ±10% of the measured mean.

First, use **Eq 3** to find the standard deviation of the measurement, σ_μ:

$$\sigma_\mu = \frac{\sqrt{61}}{\sqrt{61}} = 1.00.$$

The estimate of the mean of a Gaussian signal has a Gaussian distribution. You can therefore use a Q function to compute the probability that the estimate differs from the true mean by more than ±10%. In this case, *Tests that can have only two results—pass or fail—fit the binomial distribution.*

the estimate is 20, so you want to find if the estimate and the mean differ by more than ±2.

The probability of exceeding the mean by 2.0 is

$$P_G(m > \mu + 2\sigma_\mu) = Q(2.0) = 0.023.$$

Because a Gaussian distribution is symmetrical about its mean, $P_G(m<\mu-2.0\sigma_\mu)=0.023$, so

$$P_G(|m - \mu| < 2\sigma_\mu) = 1 - 2 \times 0.023 = 0.954.$$

You are 95.4% confident that your measurement error is less than ±10%. Thus, 95.4% of the measurements done by averaging 61 samples will be within ±10% of the true mean.

In the previous example, the variance of the noisy signal was known, but usually you don't know this quantity. In general, if you don't know the mean, you also don't know the variance. If you don't know the variance, you can use **Eq 4** to estimate that quantity. But when σ is uncertain, you must establish a confidence interval for your value of σ.

If you have to estimate σ, you must broaden the confidence interval. When you broaden it, you either increase the error and hold the confidence level constant or you hold the accuracy of your measurement and decrease the confidence level. Student's t-distribution, tabulated in most books on statistics, gives you the confidence intervals when σ is unknown. For N greater than about 50, the broadening isn't significant.

If you want to be 99% confident of the accuracy of your measurement, you must increase the number of samples that you measure. Referring to the previous example again,

$$1 - 2Q\left(\frac{\eta}{\sigma_\mu}\right) = 0.99,$$

where η is the maximum error that you can make in estimating the mean and still have 99% confidence in your estimate. Using the inverse Q function, you can find that

$$\eta/\sigma_\mu = Q^{-1}(0.005) = 2.576.$$

Because $\eta=2.0$ and $\sigma_\mu=\sqrt{61}/\sqrt{n}$,

$$n = \frac{61}{0.776^2} = 101.$$

To increase the confidence level from 95 to 99%, you must increase the number of trials from 61 to 101.

Often, you don't need to measure a parameter exactly. You simply want to know whether a part is acceptable within certain limits. In these cases, a hypothesis test is sufficient because it separates good and bad batches or systems. An estimate can take on many values, but a hypothesis test must be true or false. In such a test, you state a hypothesis about a characteristic of a population. You assume your hypothesis is true until you accumulate results that refute it **(Ref 6).**

A hypothesis test requires fewer trials than an estimate. For example, if a receiver whose bit-error rate spec is 10^{-3} makes no bit errors in 10^4 trials, you can probably pass the receiver. You haven't tested the apparatus enough to know what its actual bit-error rate is, but you don't care because you're pretty sure you've met your spec.

Because the acceptance of the hypothesis is based on statistics, you can conduct a hypothesis test incorrectly. There are two categories, or types, of errors. In a Type I error, the hypothesis is true, but you reject it. In a Type II error, the hypothesis is false, but you accept it.

To minimize such errors, you must establish criteria for accepting a hypothesis. For example, you can decide that if you measure a mean that is within $\pm1.0\sigma$ of the desired mean, the hypothesis is true. If the mean is 1.0, the probability that your results fall outside $\pm1.0\sigma$ is 0.317. Thus, the probability of making a Type I error, α, is 0.317.

The probability of committing a Type II error, accepting a hypothesis when it is false, β, depends on the actual value of the measured parameter. For instance, if your hypothesis is that μ equals 1.000, but actually μ is $1+.001\sigma$, you will almost certainly accept the hypothesis. Because the hypothesis is almost true, β equals the probability of accepting the hypothesis when it is true: $\beta\approx1-\alpha$. Because α is normally small, $\beta\approx1$. But if in actuality μ is $1+6\sigma$, the test results produce an estimate of the mean that exceeds 1.000, so β is nearly zero.

An example best illustrates how to use the hypothesis test. Suppose you have a radar receiver with a signal-detection probability spec, p, of 0.9. You want to pass at least 90% of the good receivers, which means that you set α equal to 0.1.

Any set of N trials that has only two possible outcomes fits a binomial distribution. If $p=0.9$,

$$\mu = Np = 0.9N$$
$$\sigma_\mu = \sqrt{Npq} = 0.3\sqrt{N}.$$

The next step is to calculate the critical value, C. In a

You never perform an infinite number of measurements, but you can use the Gaussian distribution when you perform a large number of tests.

hypothesis test, if the number of successes falls below C, you reject the hypothesis. You choose C so that if the hypothesis is true, the probability that the number of successes will fall below C is α. In this case, C is the minimum number of hits required to pass the receiver. The probability of achieving C or more hits when the individual hit probability is 0.9 must equal 1−α (0.9 in this example).

Assume that N is large enough that the binomial distribution approximates the Gaussian distribution. Then, using **Eq 7,**

$$P(C \le X \le \infty) \approx Q\left(\frac{C-\mu-0.5}{\sigma_\mu}\right) - Q(\infty) = 0.9.$$

Noting that Q(infinity) is zero, substitute for μ and σ_μ and use the inverse Q function to get

$$\frac{C-0.9N-0.5}{0.3\sqrt{N}} = Q^{-1}(0.9) = -1.2817$$

$$C = 0.9N + 0.5 - 0.3845\sqrt{N}.$$

If you want to perform N measurements and N=10, then C=9.5−1.2=8.3. A receiver that scores nine hits in 10 trials should exceed the specification that the detection probability is at least 0.9; a receiver that scores eight hits in 10 trials should come close to meeting the spec.

As a check on the Gaussian approximation for this test, you can evaluate the exact binomial distribution. The exact probability that the receiver scores at least eight hits in 10 trials is 0.93, slightly better than the requirement that α=0.1. The exact result doesn't agree perfectly with the Gaussian approximation, but the two results are close.

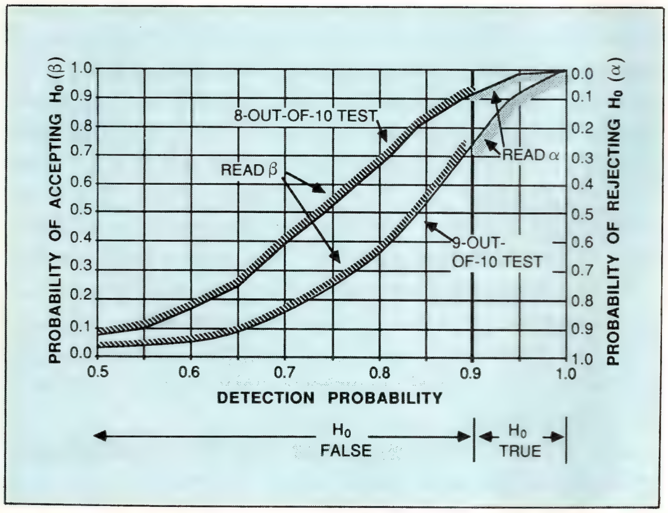

***Fig 6—The operating-characteristic function plots** the probability of accepting the hypothesis that the detection probability≥0.9. The left-hand scale shows the probability of a Type I error for an actual detection probability of less than 0.9; the right-hand scale gives the probability of a Type II error.*

You have not yet addressed the effect of Type II errors. You can't just make certain that you pass most of the good systems; you also have to be able to reject the faulty systems.

For example, you can calculate that a radar receiver with a detection probability of 0.8 has β=0.68—a 68% chance of passing. But you want to pass only receivers that meet a spec of 0.9. To reduce the chance of Type II errors, you may have to decide that your acceptance criterion should be nine hits in 10 trials, not eight.

The operating-characteristic function of the hypothesis test measures the tradeoffs you must make between Type I and Type II errors. The operating-characteristic function shown in **Fig 6** plots the probability of a receiver passing the 8-out-of-10 criterion vs the actual detection probability. It also shows the probability of passing the 9-out-of-10 criterion. The left-hand scale gives β, the probability of passing a defective receiver. The right-hand scale gives α, the probability of rejecting a good receiver.

The better a receiver's actual performance, the more likely it is to pass, but of course you also want to pass the receivers that just meet the 0.9 spec. To pass the marginal receivers, you may have to pass an 0.8-detection-probability receiver occasionally. Fortunately, the odds of passing a lemon that has a detection probability of 0.5 are less than 10%.

If your receivers must spec a detection probability of at least 0.9, you may have to improve their design so that most of them have a detection probability of 0.95. According to **Fig 6,** each receiver then has a 90% chance of passing the 9-out-of-10 criterion.

Of course, instead of redesigning your receivers, you can increase the number of trials. If you run 100 trials, for example, the acceptance criterion becomes 86 hits. A receiver with a detection probability of 0.8 would then have less than a 0.03 probability of passing. The price for this confidence level is high, however; the testing time increases by a factor of 10.

The cost of testing makes the efficiency of your test an important criterion. The average sample number (ASN) of a hypothesis test measures efficiency. Especially when tests are complex and time-consuming, or when you have large numbers of devices to test, you must calculate the ASN to judge a test's efficiency. You

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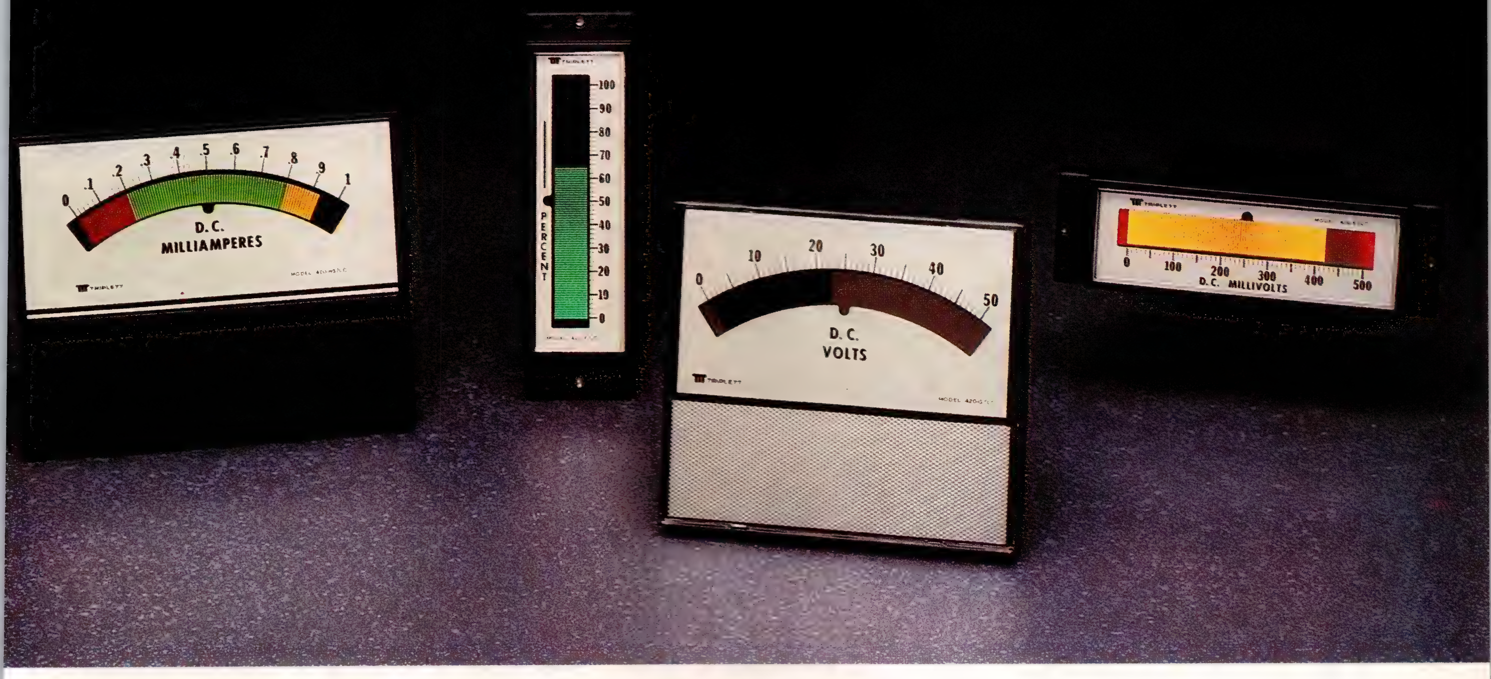

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Because such a small error in X can cause such a large error in Q, you can't ever know Q accurately enough to care about a 10^{-7} error.

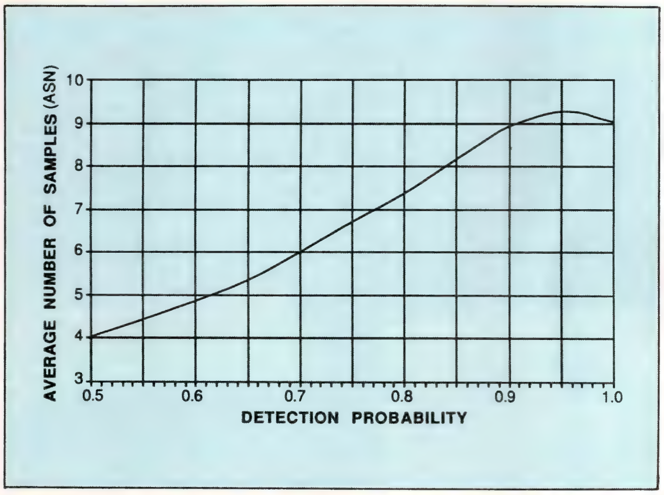

Fig 7—The average number of trials to complete the 9-out-of-10 test depends *on the true detection probability. The lower the detection probability, the shorter the test (because the system fails the test). If the detection probability is 0.93 to 0.99, the unit usually passes, but you must perform 10 trials to get nine hits. If the detection probability is one, the test always ends in nine trials.*

should select your test so that, for the chosen values of α and β, you minimize the ASN.

Fig 7 shows a curve of the ASN for the 9-out-of-10 test vs the actual detection probability. The ASN is

$$\text{ASN} = \sum_{i=2}^{10} iP(i),$$

where P(i) is the probability that you must measure i samples to complete the test. The summation goes to 10 because you have decided that you won't perform more than 10 tests. The sum begins at two because a receiver can't fail unless it misses twice.

P(i) depends on the probability that you accept the receiver, which in turn depends on the actual signal detection probability, p. If you accept a receiver, the test can't end in fewer than nine trials. You can therefore simplify your calculation by building a condition into P(i) that, when $i<9$, the receiver has failed. The probability of i trials, when $i<9$, is the probability that two misses will occur in i trials. You can express this condition as

$$P(i) = (i-1)\,p^{i-2}\,q^2 \text{ for } 2 \le i < 9.$$

P(9) is the probability that either two misses occur in nine trials (fail) or zero misses occur in nine trials (pass):

$$P(9) = 8p^7q^2 + p^9.$$

Ten trials are necessary only if you have just one miss in the first nine trials:

$$P(10) = 9p^8q.$$

Fig 7 uses these values of P(i) to find the ASN. You can use this procedure to calculate the average sample number for any statistical test. **EDN**

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Author's biography

R F Cobb, a senior scientist at Harris Corp's Government Satellite-Communications Div (Melbourne, FL), specializes in satellite-modem design. He received a BSEE from the University of Detroit and an MSEE from the Georgia Institute of Technology. Ray devotes his free time to teaching a neighborhood Bible study and running.

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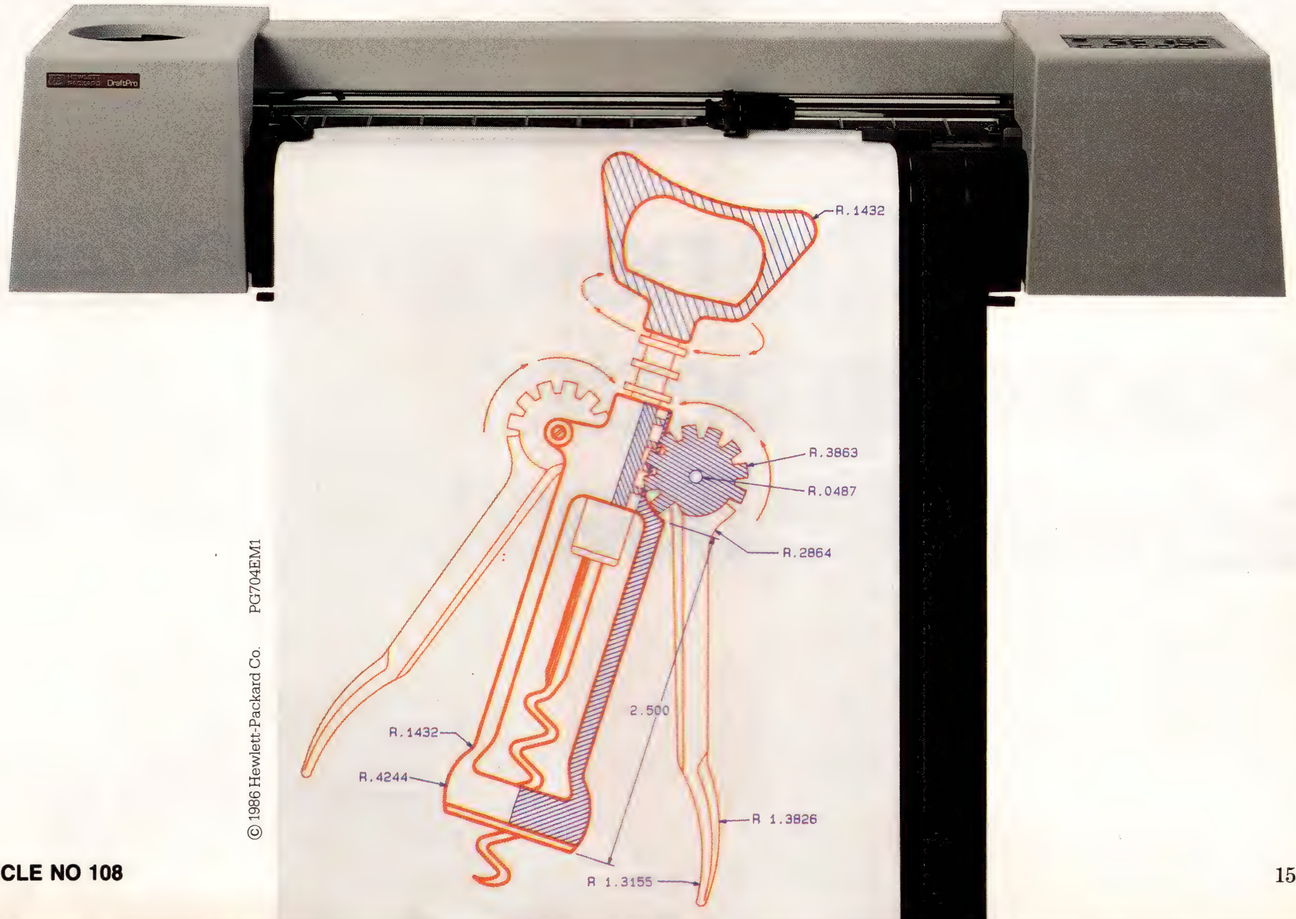

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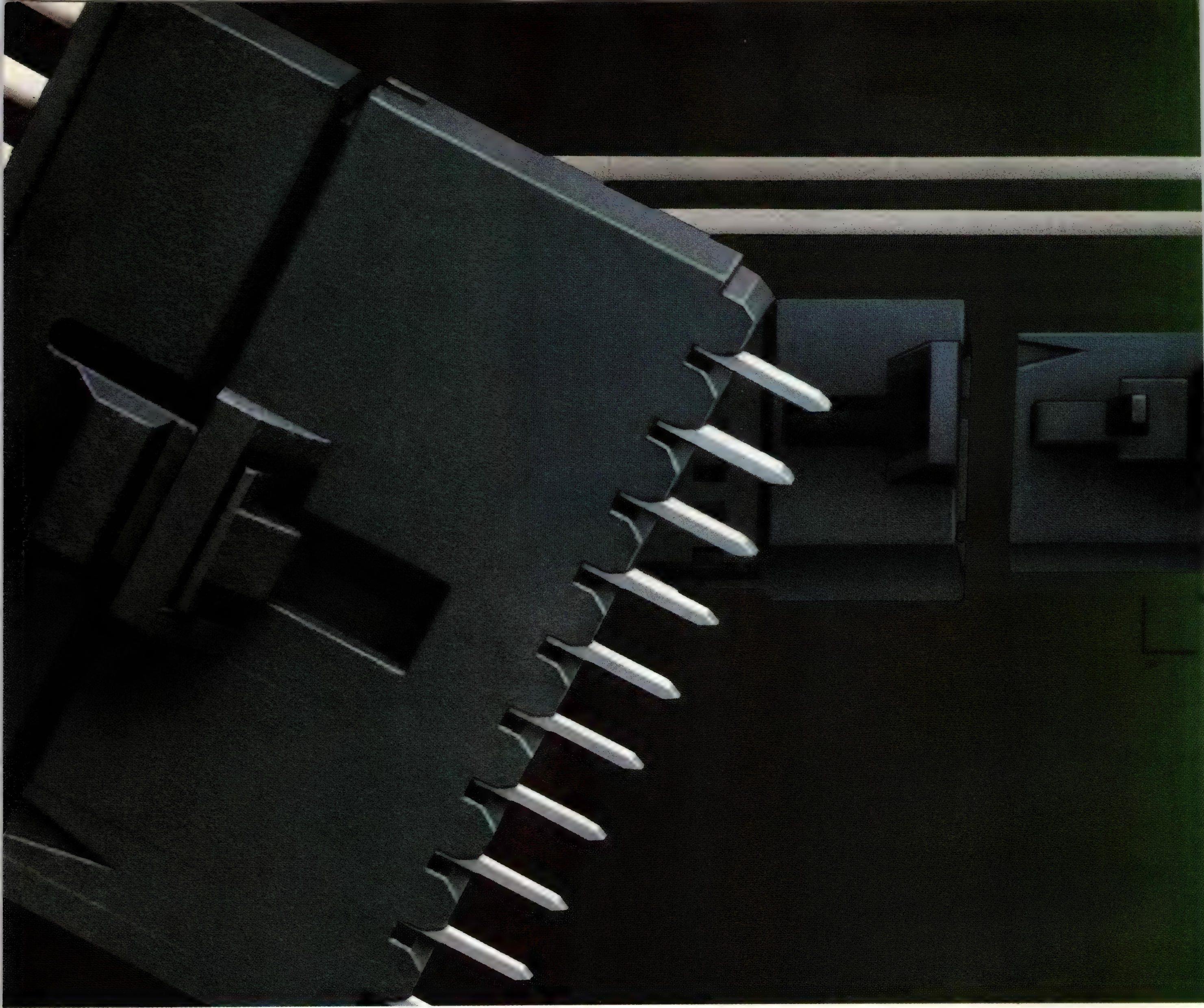

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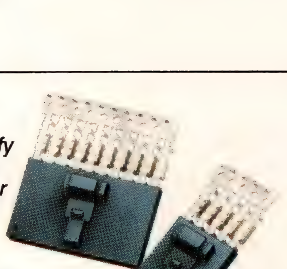

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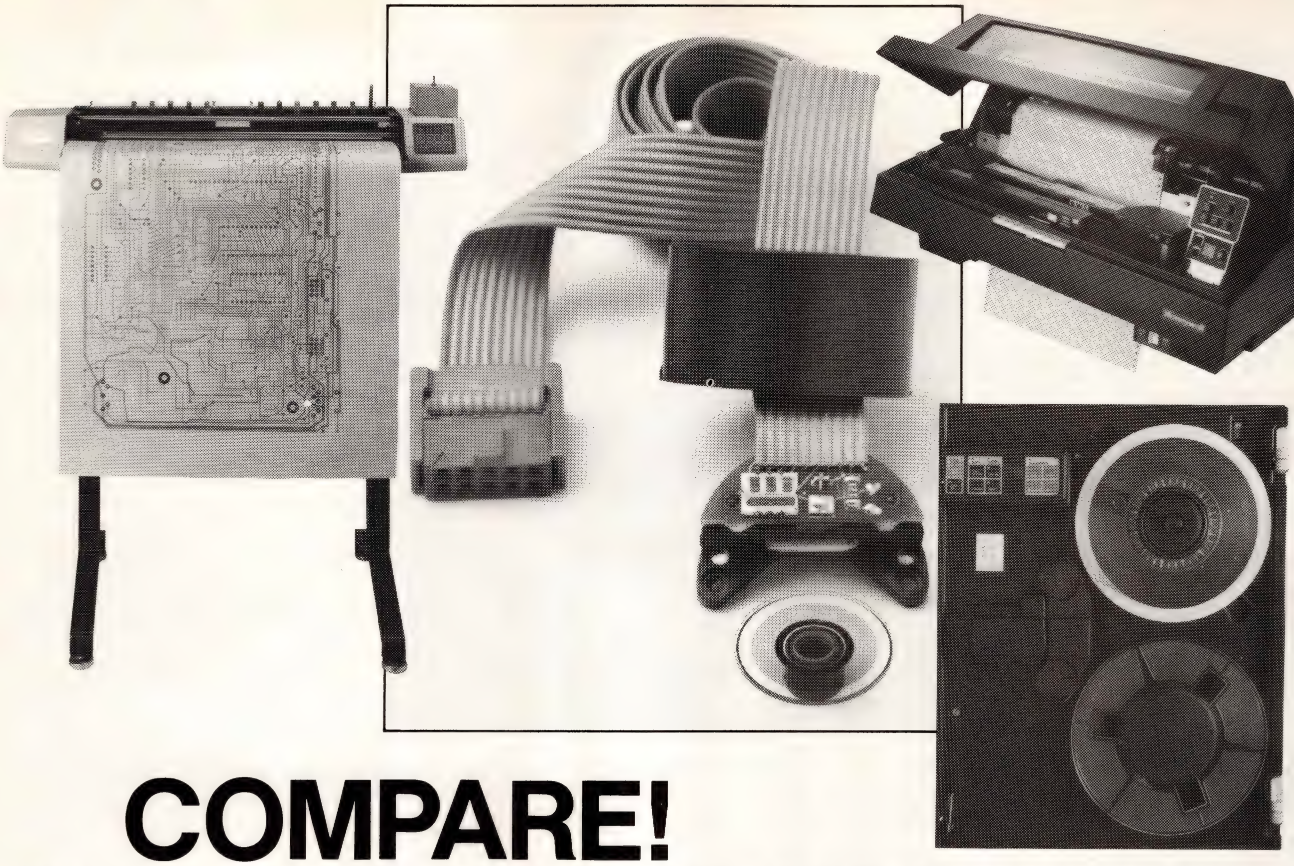

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Monolithic instrumentation amplifiers (IAs) have made significant gains on their discrete counterparts in a number of performance categories. A high-speed, fast-settling monolithic IA like the INA110, for example, proves useful in a wide variety of applications. It's easy to design the external circuitry that helps the device meet the stringent reliability requirements of industrial environments, and the speed of the device suits it to multiplexing in data-acquisition systems. Other applications exemplify the versatility of the new breed of monolithic IAs.

Overvoltages on the inputs of an instrumentation amplifier can occur in many industrial applications. Two key concerns of a system designer whose products are subject to input overvoltages are therefore reliability and the maintenance of device accuracies. With the addition of the appropriate components, the INA110 will meet the requirements for reliability and negligible shifting in device parameters.

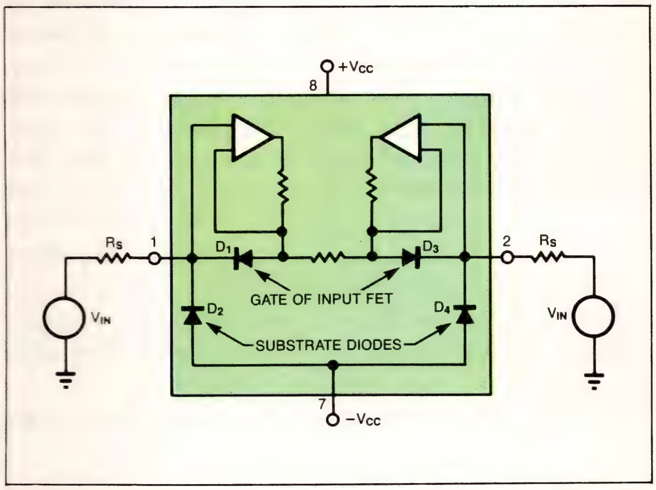

Fig 1—Internal circuitry provides current limiting *for the INA110 as long as the input voltage remains within the supply-voltage range. To protect against overvoltage conditions, you should add external current limiting resistors (R_S).*

The simplified diagram of the INA110 in **Fig 1** can help you to understand the basics of input overvoltage protection. As you can see, D_2 and D_4 cannot conduct for values of V_{IN} within the supply-voltage range. D_1 and D_3, however, can conduct, but the currents flowing out of the device are internally limited. The external current-limiting series resistor, R_S, is therefore unnecessary whenever the input voltage remains between the supply voltages.

More design care is required whenever V_{IN} exceeds either supply voltage. Notice that when V_{IN} is 0.6V below $-V_{CC}$, D_2 and D_4 conduct without an internal current-limiting resistor. When V_{IN} is 4V above $+V_{CC}$, the reverse breakdown of all diodes may occur, and there is no current limit provided for current through D_2 or D_4. To protect the device properly, you should externally limit input currents to less than 1 mA; that is, R_S should be greater than

$$\frac{V_{IN(MAX)} - V_{CC(MIN)}}{1\text{ mA}}.$$

The offset voltage (V_{OS}) and other input-referred parameters are directly related to the input FET's gates (D_1 and D_2), and these gates typically break down before diodes D_3 and D_4 do, so the manufacturer devised the following performance test to evaluate the shift in the INA110's parameters that occurs in response to overvoltage conditions. Sample units were driven at each input with 1 mA ac pk at 60 Hz for 24 hours at room temperature, after which guaranteed parameters from the product data sheet were tested. The tests indicated no significant shifts in those parameters, but to guarantee that the device maintains accuracy under overvoltage conditions of extended time or at elevated temperatures, it's still good design practice to protect the input FET's gates from breakdown. To do so, you add, along with the properly selected series resistor, external low-leakage clamp diodes, placed from each input to $+V_{CC}$.

Building on these basic design techniques, you can go beyond input protection and provide some form of signal conditioning. **Fig 2**, for example, shows a 300-Hz lowpass filter with 220V ac input protection. The 500-kΩ, ⅛W resistors provide the required power dissipation at 220V ac and limit input current into the device to 700 μA for a 350V pk input voltage. You should use metal-film resistors, because many other resistor types exhibit excessive low-frequency noise, which may degrade the circuit's performance.

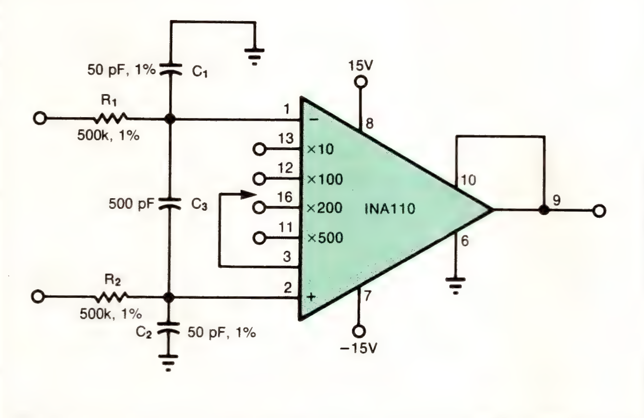

Fig 2—This combination input-filter and overvoltage-protection circuit *employs a 300-Hz lowpass filter and provides input protection from 220V ac.*

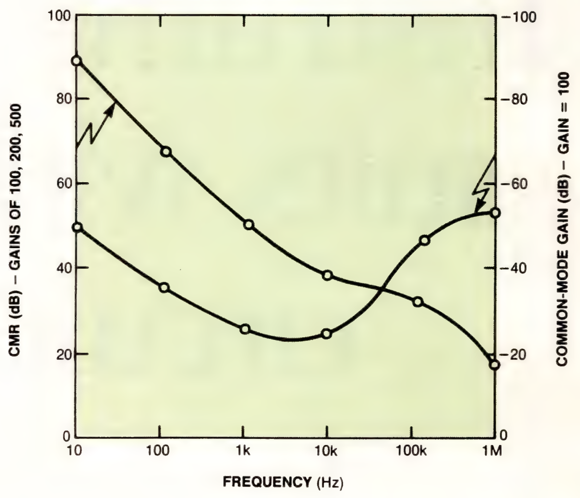

Fig 3—You can improve the common-mode rejection *for worst-case mismatches of time constants R_1C_1 and R_2C_2 in the* ***Fig 2*** *circuit by adding a small trimming resistor in series with R_1 and R_2.*

The use of R_1 and R_2 without additional capacitors would yield extremely poor common-mode rejection (CMR), resulting from unequal capacitances on the inputs. You can alleviate the mismatch in input capacitance through use of shunting capacitor C_3. You obtain the desired cutoff frequency from the equation

$$f(-3\text{ dB}) = \frac{1}{2\pi 2R_1 \times (C_3 + \frac{C_3}{2}},$$

where $R_2 = R_1$ and $C_2 = C_1$. Input filtering also improves the S/N ratio by reducing the thermal noise of R_1 and R_2, because the thermal noise (V_N) is a function of bandwidth:

$$V_N = \sqrt{4kTR \times \text{bandwidth}},$$

where k is Boltzmann's constant, T is the

Two key concerns of a system designer whose products are subject to input overvoltages are reliability and the maintenance of device accuracies.

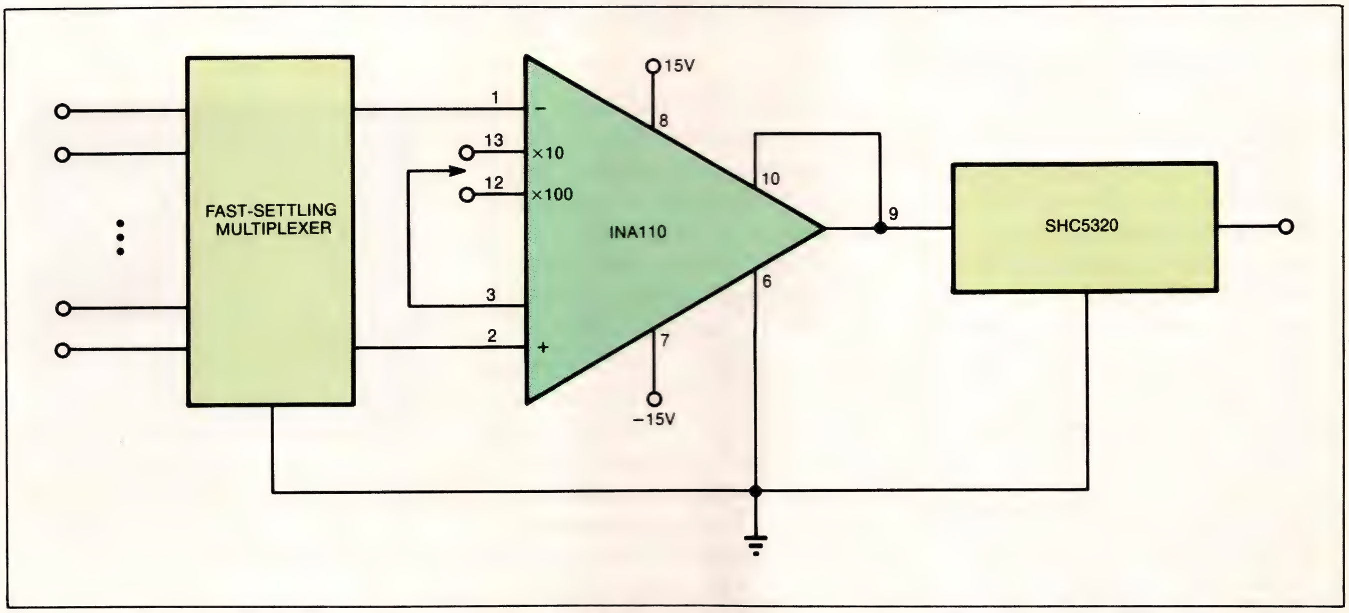

***Fig 4—You can build a multichannel data-acquisition system** that has gains of 10 or 100, using the INA110, the SHC5320 to perform the sample-and-hold function, and an MPC800 or MPC801 multiplexer, which settles to within 0.01% in less than 1 μsec.*

temperature in degrees Kelvin, and R is the resistance.

Fig 2's circuit assumes a cutoff frequency of 300 Hz—a cutoff frequency used in many transducer applications. For practical component tolerances of 1%, C_3 should be much larger than C_1 and C_2 to minimize the differences in the time constants R_1C_1 and R_2C_2. C_1 and C_2 do improve high-frequency CMR, however, and they diminish the familiar problem of RFI rectification, so you must make a tradeoff in the ratio of C_3 to C_1 in order to obtain optimum CMR at both low and high frequencies. **Fig 3** shows CMR and common-mode gain vs frequency for worst-case mismatches of values in the circuit. You can further improve the circuit's CMR by adding a small trimming resistor in series with R_1 and R_2 to match time constants R_1C_1 and R_2C_2 to one another.

The performance of the FET-input monolithic IA in this example compares favorably with the performance a premium bipolar IA could achieve. The bipolar IA would introduce a 5-mV input-referred error, which is the product of the input offset current (I_{OS}, 10 nA) and the 500-kΩ resistor; the input-referred error of the FET-input IA would be only 12 μV. You could add a V_{OS} trimming resistor to the bipolar IA, but such a resistor will typically introduce a 3.3-μV/°C offset voltage per 1 mV trimmed. Consequently, the bipolar device will drift in excess of 16 μV/°C, compared with a maximum of 2 μV/°C for the FET-input device.

The error introduced by flicker noise from the bias currents reacting with the 500-kΩ resistor in a bipolar IA circuit will be the dominant noise source, whereas the FET-input IA has negligible current noise—five to 10 times lower overall. I_{OS} drift in a bipolar IA further degrades performance, showing the necessity of a FET-input IA in applications requiring large input impedances.

The speed of the INA110 renders the device suitable to the type of high-speed data-acquisition channel

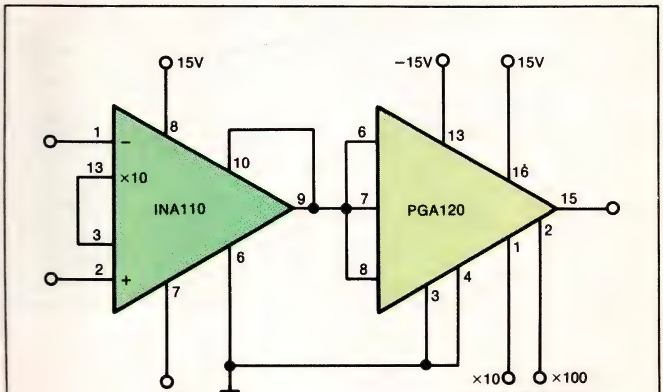

***Fig 5—You can build a digitally controlled, fast-settling, programmable-gain IA** when using the INA110 as a front end for PGA102 programmable-gain amplifier.*

A look inside the INA110

The INA110 is a variation of the classic 3-op-amp instrumentation amplifier **(Fig A)**. Its FET inputs make possible the use of a differential-input IA in many high-input-impedance applications, as described in the main text. The speed of this monolithic IA **(Fig B)** suits it to fast data acquisition with multiplexed inputs, to use in gain blocks with high gain-bandwidth products, and to other applications requiring fast settling or a high gain-bandwidth product. Pin-strappable gains increase the device's utility in a variety of applications. The IA is pin compatible with the AD524/624.

Cascoding of the input FETs results in maximum input bias currents of 50 pA, an input impedance of $2\times10^{12}\Omega$, and a high-gain CMR greater than 106 dB. Cross-coupling of the input amps and careful thermal layout are additional factors contributing to the INA110's CMR and dc error figures. These techniques cancel thermal feedback, keeping nonlinearity below 0.01% with a 2kΩ load. The laser-trimmed thin-film resistors help keep gain error low with many gain figures and imparts a level of temperature tracking not achievable with standard discrete components.

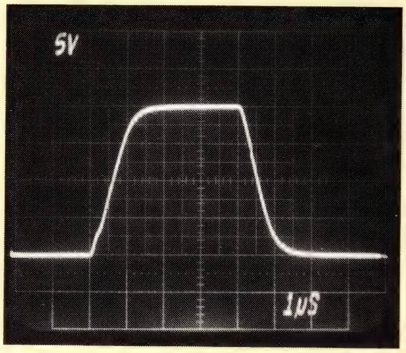

Fig B—This scope photo shows the large signal-step response *of the INA110 with a gain of 100. The slew rate is 17V/µsec, the bandwidth is 470 kHz, and the gain-bandwidth product is 47 MHz.*

The ability to compensate V_{OS} temperature drift at the wafer level allows a FET design to achieve bipolar level drifts of below 2+(50/gain) µV/°C. Low-noise design and processing techniques achieve an input-referred noise of only 10 $\text{nV}/\sqrt{\text{Hz}}$, which is the same noise level you'd see in an IA that contains two low-noise OPA111s in the front end.

The high-speed characteristics of the INA110 stem from the use of JFETs, rather than conventional lateral PNPs, as high-speed level shifters. A feedback scheme affecting both open-loop and closed-loop characteristics is responsible for the bandwidth's varying only from 2.5 MHz to 470 kHz as the gain varies from 1 to 100. For gains of 1, 10, and 100, the settling times to 0.01% of a 20V step are only 5, 3, and 4 µsec, respectively. A slew rate of 17V/µsec results in a full-power response of 270 kHz.

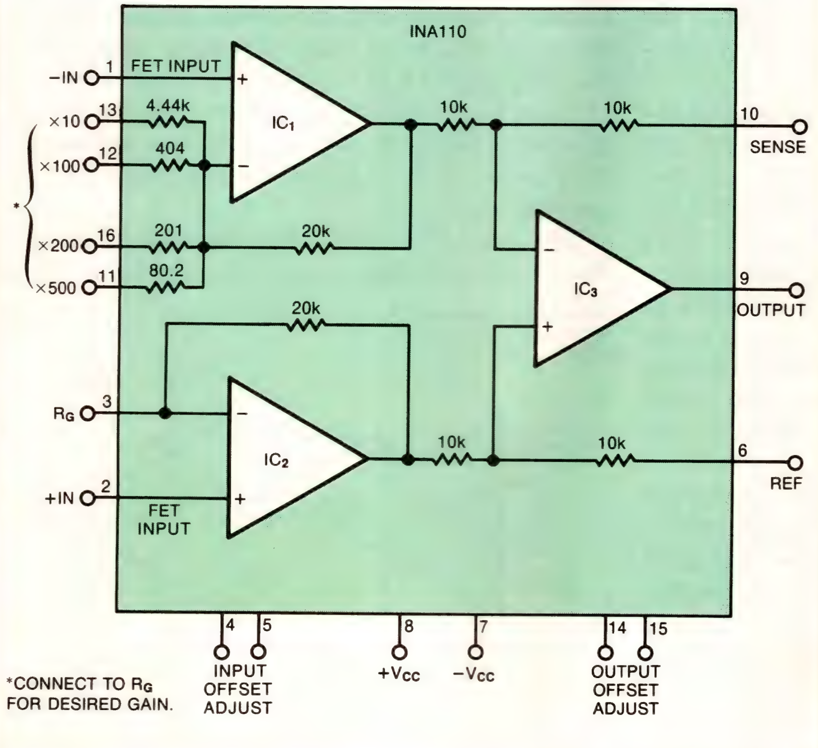

Fig A—The INA110 is a variation *of the familiar 3-op-amp IA. The device features FET inputs and pin-strappable gains.*

Building on some basic design techniques, you can go beyond input protection and provide some form of signal conditioning.

shown in **Fig 4.** Using a multiplexer that settles to within 0.01% in less than 1 μsec (such as an MPC800 or MPC801), the SHC5320 to perform the sample-and-hold function, and the INA110, you can achieve 12-bit acquisition times of 5 μsec with gains of 10 and 100. The 5-μsec acquisition time translates to a sample rate of 200 kHz, allowing 12-bit sampling of four audio channels.

The low-level output signal of many transducers requires amplification by a factor of 100 for useful processing. For an industrial sensing application, a single INA110 with a gain of 100 can continuously sample more than 150 channels, maintaining a 500-Hz bandwidth for each channel and providing the necessary amplification of the signals. The V_{OS} error, a result of the interaction of the input bias current and the multiplexer's on-resistance, is negligible, because the input bias current stays at the picoampere level.

A configuration for programmable gain

In yet another application, **Fig 5** shows the INA110 coupled with a PGA102 programmable-gain amplifier to produce a digitally controlled, fast-settling, programmable-gain IA. You can program gains of 10, 100, and 1000 with 0.01% settling times of 6, 6, and 12 μsec, respectively. Gain ranging can increase the output voltage (V_{OUT}) to within 20 dB of full scale to the next stage. When you're multiplexing many channels with different full-scale levels to the input of the IA, it's particularly useful to be able to adjust the amplification of each signal in order to increase the dynamic range of the circuit. The gain-ranging technique increases the dynamic range of the circuit by as much as 40 dB, thereby assuring maximum input sensitivity.

Another application makes use of the common-mode voltage to cancel input noise injected into the circuit through the input leads. **Fig 6** shows an IA with gains of 1000 and 10,000 and input-referred noise of 4 $\text{nV}/\sqrt{\text{Hz}}$. In this circuit, V_{OS} is held below 50 μV, and two low-noise OPA37 op amps provide 40 dB of differential gain. The INA110 performs differential-to-single-ended conversion in gains of 10 or 100, resulting in respective circuit gains of 1000 or 10,000. The minimum dc CMR is 108 dB and typically exceeds 120 dB. AC CMR is usually a function of the parasitics associated with the input lines. Because the bandwidth of the common-mode drive point matches the signal bandwidth of 500 kHz, and because the slew rate is above 11V/μsec, an input shield or guard driven by the common-mode signal (V_{CM}) will greatly improve ac CMR. The discrete design of this circuit allows you access to V_{CM} for this purpose. (Settling-time considerations are important for this circuit; see **box,** "The limit of performance: Speed or resolution.")

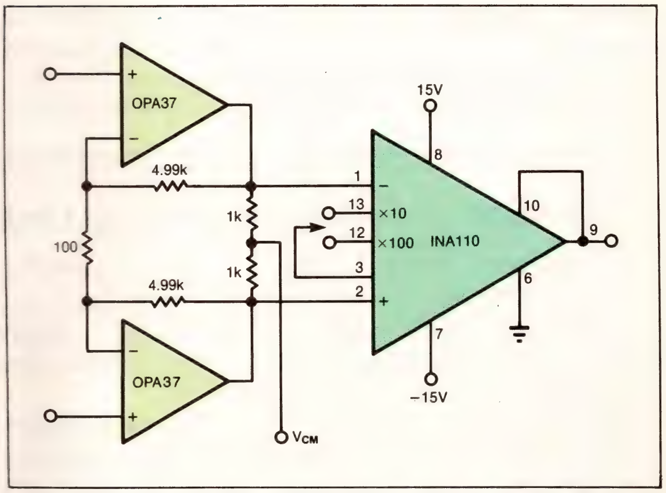

***Fig 6—You can use the common-mode drive** on this high-gain, low-noise IA to improve the circuit's ac common-mode rejection.*

Current sensing in 4- to 20-mA loops

An instrumentation amp like the INA110 serves in current-sensing applications, where a small differential voltage of interest ($I \times R_{SENSE}$) is superimposed upon a large common-mode voltage. **Fig 7** shows an IA with a ±100V common-mode range and an input impedance

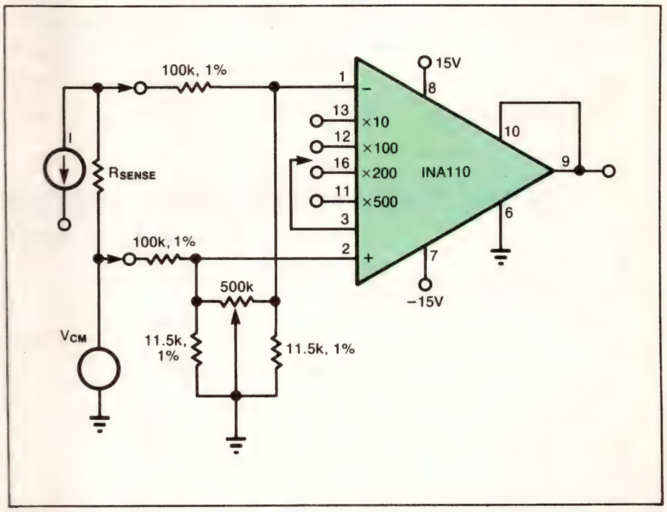

***Fig 7—You divide down the inputs** to improve the common-mode range of this IA circuit. Doing so allows you to use the IA in such applications as current sensing in a current loop, where the signal is a small differential voltage impressed upon a large common-mode voltage.*

greater than 100 kΩ. The circuit is well suited to receiving a signal on a 4- to 20-mA current loop. If R_{SENSE} is equal to 50Ω and the INA110 is set for a gain of 100, you obtain a full-scale output of 10V when a 20-mA current flows through R_{SENSE}. The wide common-mode range of the circuit accommodates the large voltage drops, which can occur in the very long wires of a current loop.

The limit of resolution: Settling time or noise?

Key concerns in many analog applications are not only how much resolution is possible, but also how long it takes the output to reach the desired accuracy in response to an input change. Manufacturers specify settling time as the time it takes the output to reach the desired accuracy, or error band, after an input-voltage step. In many applications, however, settling time is not the only specification of concern.

The reason? The industry-standard method for testing settling time may not match the user's application. The test uses a periodic waveform and averages out noise by averaging samples over many periods. This technique gives a figure for the settling time that's independent of the noise level. For applications with nonperiodic signals—for example, when an instrument is looking at a single event—you must also consider the output-noise level when computing settling times.

Compare noise to error band

To determine if the output-noise level is a problem, you should make a comparison of the error band to that output-noise level. The peak output noise is equal to a factor of 3 multiplied by the product of the input noise, the gain, and the square root of the noise bandwidth, where the noise bandwidth is the effective bandwidth of the amplifier's input noise. For most instrumentation amplifiers, the noise bandwidth closely approximates the small signal bandwidth multiplied by 1.57. If the output-noise level is higher than the error band, then you must filter or average the output to reduce the noise bandwidth and achieve the desired resolution. In a case such as this one, the required filtering, and not the settling time of the amplifier, determines the system speed. In **Table A** you will find maximum noise bandwidths for various input-noise levels, gains, and desired resolutions for a 20V full-scale output.

The chart shows that for high gain or high resolution, the input-referred noise becomes the key concern for a fast-settling amplifier. Although low noise is rare in FET-input designs, the INA110 specs an input-referred noise level of only 10 nV/$\sqrt{\text{Hz}}$, allowing 12-bit resolution with gains to 100 and settling times of 5 μsec or less. For those applications requiring even lower noise, you can use a discrete design that employs bipolar input OPA37s, like the one described in the main text (see **Fig 6**).

TABLE A—MAXIMUM NOISE BANDWIDTH WITH RESPECT TO INPUT NOISE, GAIN, AND RESOLUTION

INPUT-REFERRED NOISE (nV/$\sqrt{\text{Hz}}$)	GAIN	MAXIMUM NOISE BANDWIDTH (Hz) 8 BITS	12 BITS	16 BITS
4	10	110G	400M	1.6M
10	10	17G	64M	260k
16	10	6.6G	25M	100k*
4	100	1.1G	4.0M	16k*
10	100	170M	640k	2.6k*
16	100	66M	250k*	1.0k*
4	1k	11M	40k*	160*
10	1k	1.7M	6.4k*	26*
16	1k	660k	2.5k*	10*

* AN AMPLIFIER WITH A 0.01% SETTLING TIME OF 5 μSEC AND A 0.001% SETTLING TIME OF 10 μSEC WILL BE LIMITED BY THE TIME REQUIRED TO LIMIT THE NOISE BANDWIDTH TO THE VALUE SHOWN.

The performance of the FET-input monolithic IA compares favorably with the performance a premium bipolar IA could achieve.

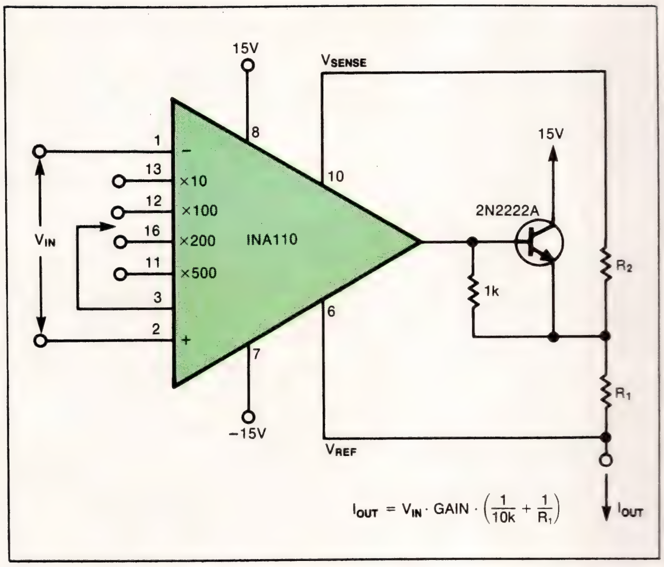

***Fig 8—This voltage-to-current converter** uses the INA110, two resistors, and a current-boosting transistor to provide the current for a 20-mA current loop.*

The common-mode range of the circuit extends to ±100V when you divide down both input signals by a factor of 10. The circuit also attenuates the differential signal by 10, so

$$V_{OUT} = I \times R_{SENSE} \times \frac{\text{IA gain}}{10}.$$

Common-mode error results from mismatches in the input attenuators, but you can trim these errors with the 500-kΩ potentiometer connected between the attenuators and common. R_{SENSE} also creates a CMR error, which you can cancel by adding a resistor of equal value in series with the 100-kΩ resistor in the positive input, or by trimming the 500-kΩ potentiometer. To condition the inputs, you can add input filtering at the inputs of the IA using techniques similar to those described earlier.

Converting voltage to current

The current-loop mode of data transmission is very popular in many harsh environments, where differential inputs are required for common-mode rejection of noise as well as for detection of a small differential signal on top of a large common-mode signal. You can use an IA as the front end in the voltage-to-current converter that's required in current-loop applications. **Fig 8** shows how you can build a complete differential voltage-input and current-output circuit with only two precision resistors, a current-boosting transistor, and an IA. The IA creates a voltage equal to V_{IN}×gain between V_{SENSE} and V_{REF}, causing output current (I_{OUT}) to flow as determined by the equation

$$I_{OUT} = (V_{IN} \times \text{gain}) \div \frac{10kR_1}{10k + R_1},$$

where the 10 kΩ is the input impedance of the reference point. R_2 cancels errors resulting from the voltage difference between V_{REF} and the internal common-mode voltage. R_2 must therefore match R_1 to maintain a high output impedance. The current-boosting transistor inside the feedback loop keeps the high power dissipation off the chip and lowers the output current of the IA to the rated level for guaranteed dc performance. The sense point closes the feedback loop and allows you to put the power-boosting function inside the feedback loop, where errors are divided down by the loop gain of 1,000,000. The 1-kΩ resistor from the base to the emitter of the current-boosting transistor forms a return path for current out of the reference and sense terminals when I_{OUT} is zero.

When R_1 and R_2 are equal to 50.25Ω, you obtain a 0- to 20-mA I_{OUT} for a V_{IN}×gain product within the range 0 to 1V. The voltage at the V_{REF} point may be between +10V and −10V, which allows for voltage drops along a current loop. **EDN**

Author's biography

Rod Burt is a design engineer with Burr-Brown's Analog Div (Tuscon, AZ), where he is responsible for the design and development of analog components. Rod attended the University of Arizona and has been with Burr-Brown for four years. The father of four children, Rod says spending time with his family is his spare-time activity.

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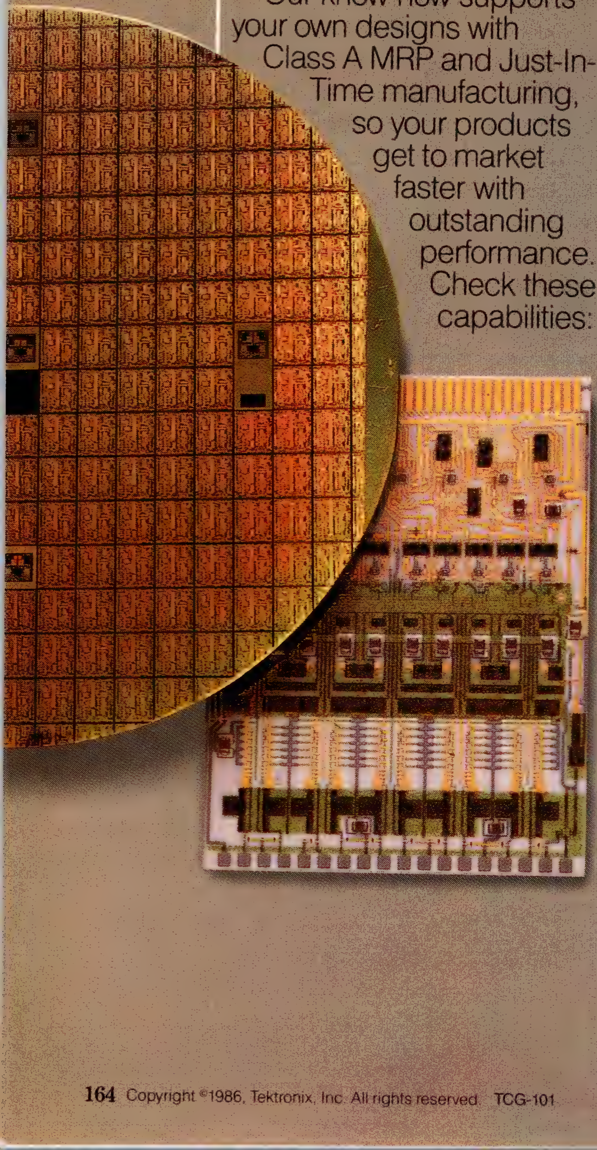

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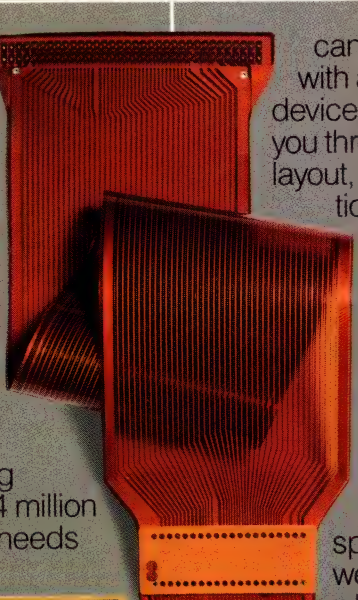

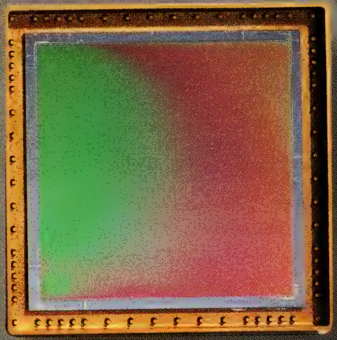

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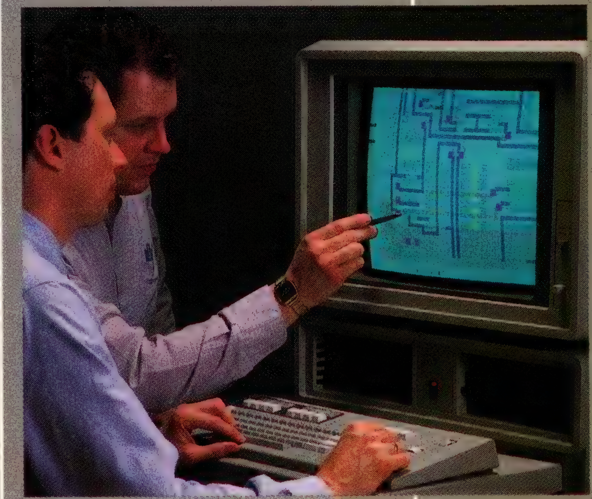

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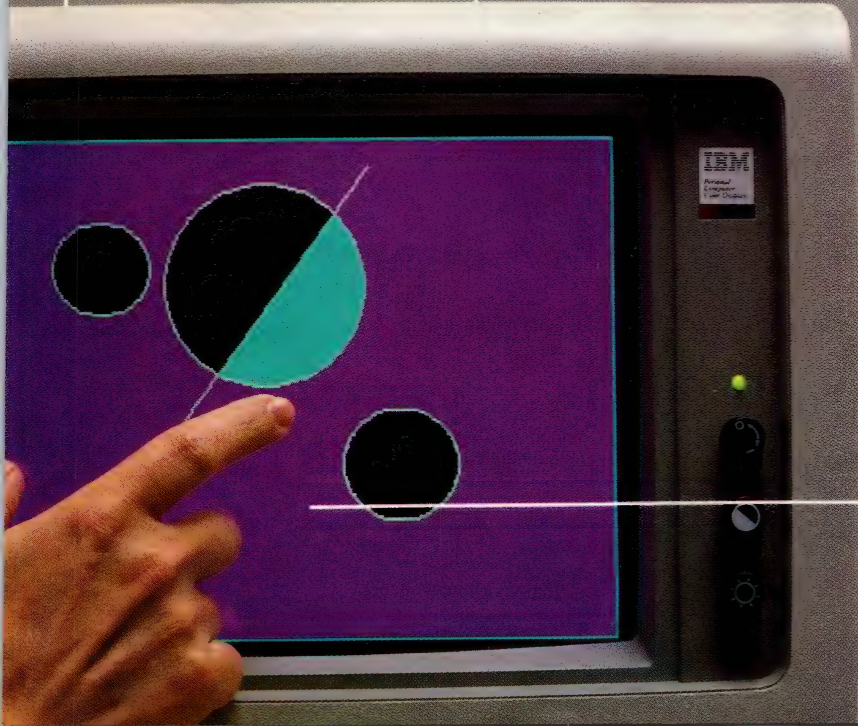

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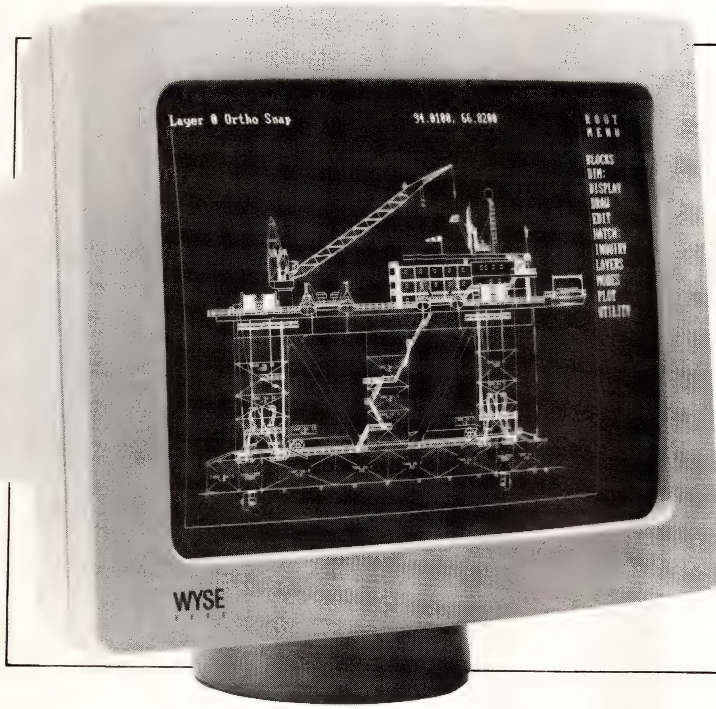

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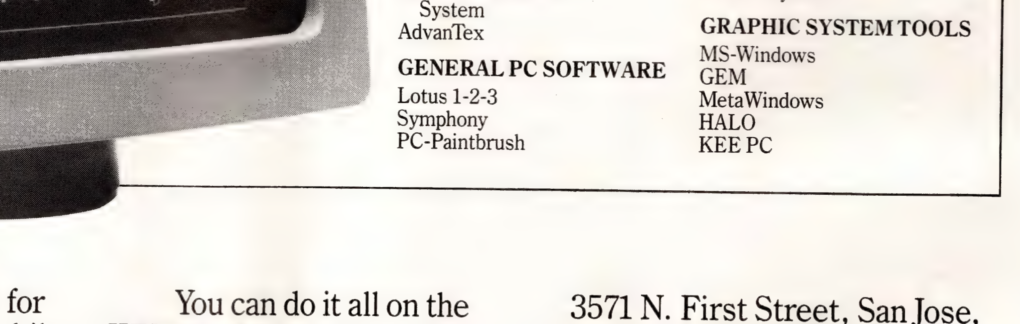

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CIRCLE NO 112

Interface your PC to the Multibus

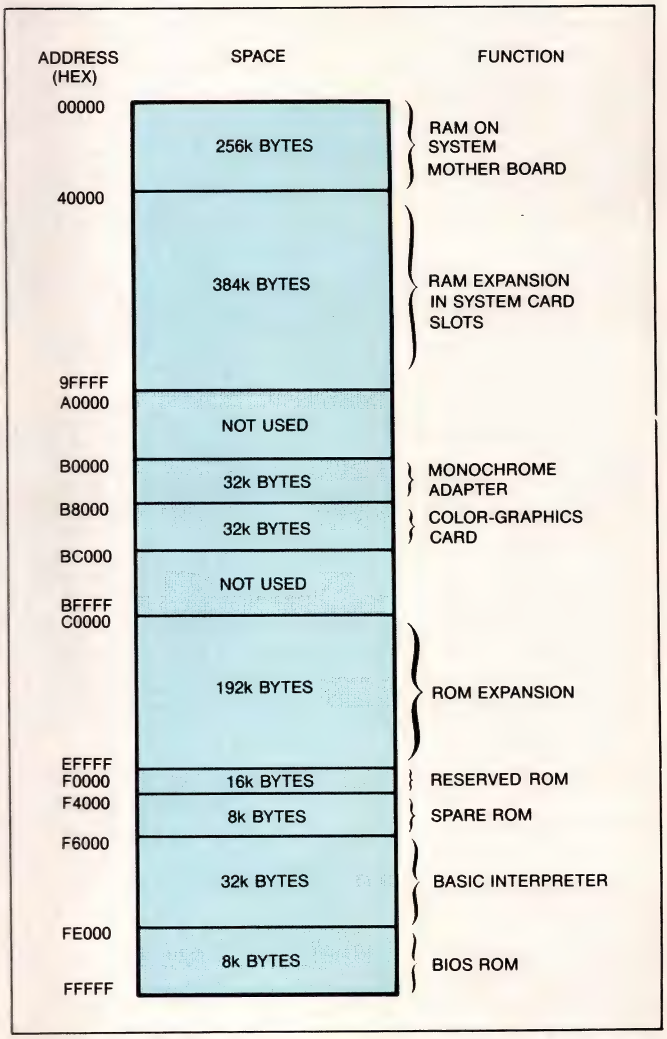
Even if you don't have a full set of development software for your Multibus system, you can still test your Multibus products: A hardware interface between an IBM PC and a Multibus system will let you run your Multibus test programs on the IBM PC.

William H Robertson, *KLA Instruments Corp*

It's not uncommon to find that the software tools you need for developing and testing a product are either not commercially available or, if available, are prohibitively expensive. This situation is particularly likely to arise when you're dealing with MIL-STD-1750A hardware, but it can arise when you're using Multibus and VME Bus products, too. An IBM PC or compatible machine can offer a possible solution, provided that you can make your PC communicate directly with the product you're developing.

For example, suppose that you need to develop diagnostic programs to verify a variety of Multibus memory and I/O boards, but you have software-development tools only for the IBM PC. By implementing a hardware interface between your PC and a Multibus expansion chassis, you can use programs residing on the PC to control and exercise your Multibus boards.

To develop such a bus-conversion interface, you must first understand exactly what functions the interface must provide. The ideal bus interface is transparent to the host system: The host should perceive no difference



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CIRCLE NO 113

You can use a simple PC bus extender to pass data, address, and control signals to more complex bus converters for the Multibus, VME Bus, and other standard buses.

between an access to its own internal memory or I/O space, and an access to memory or I/O that is resident on the external bus. The bus interface between the two systems should provide all protocol-handling functions, such as signal timing and additional wait states; similarly, the host should be able to perform all I/O accesses, interrupt servicing, and DMA operations for both systems in exactly the same manner. Depending on your application, therefore, the interface may have to provide address mapping for memory or I/O addresses on the external bus that are inaccessible to the host or that duplicate addresses needed by the host for other functions.

Keep in mind that not every application will allow for a completely transparent interface. A transparent interface won't be possible, for example, when the host bus is a high-speed bus with no facility for slow data transfers, or when you're interfacing an 8-bit data bus to a 32-bit data bus that doesn't provide facilities for byte-wide data transfers. Neither will a transparent interface be possible when the external bus has a memory or I/O space that's larger than the host can support.

Nontransparent operations involve knowledge of the external bus; you'll need to arrange for special facilities to perform these operations. Such special facilities might consist of software drivers and additional bus-conversion logic to handle all external bus communication. For example, if the external bus has a larger memory-address space than the host does, you can

Text continued on pg 172

TABLE 1—I/O MAP FOR THE IBM PC

HEX RANGE	USAGE
000-00F	DMA 8237A-5
020-021	INTERRUPT 8259A
040-043	TIMER 8253-5
060-063	PPI 8255A-5
080-083	DMA PAGE REGISTERS
0AX	NMI MASK REGISTER
0CX	RESERVED
0EX	RESERVED
200-20F	GAME CONTROL
210-217	EXPANSION UNIT
220-24F	RESERVED
278-27F	RESERVED
2C0-2DF	AST "SUPER PAK" CARD
2F0-2F7	RESERVED
2F8-2FF	ASYNCH COMM (SECONDARY)
300-30F	MM58274 REAL-TIME CLOCK
310-31F	OTHER PROTOTYPE CARDS
320-32F	FIXED DISK
378-37F	PRINTER
380-38C	SDLC COMM
380-389	BS COMM (SECONDARY)
3A0-3A9	BS COMM (PRIMARY)
3B0-3BF	IBM MONOCHROME DISPLAY/PRINTER
3C0-3CF	RESERVED
3D0-3DF	COLOR/GRAPHICS
3E0-3E7	RESERVED
3F0-3F7	DISKETTE
3F8-3FF	ASYNCH COMM (PRIMARY)

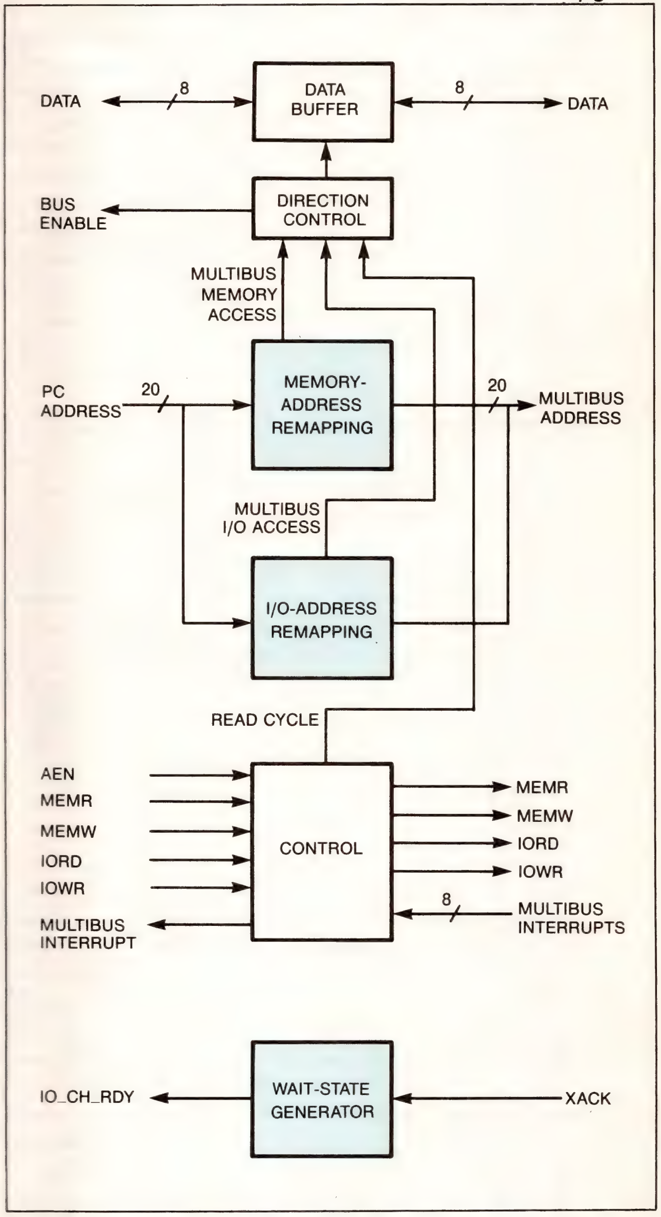


***Fig 2—The PC/Multibus converter board remaps addresses** generated by the PC to appropriate Multibus addresses. The board has separate remapping facilities for memory addresses and I/O addresses. It can also add PC wait states in order to make the data-transfer speeds of the two systems match.*

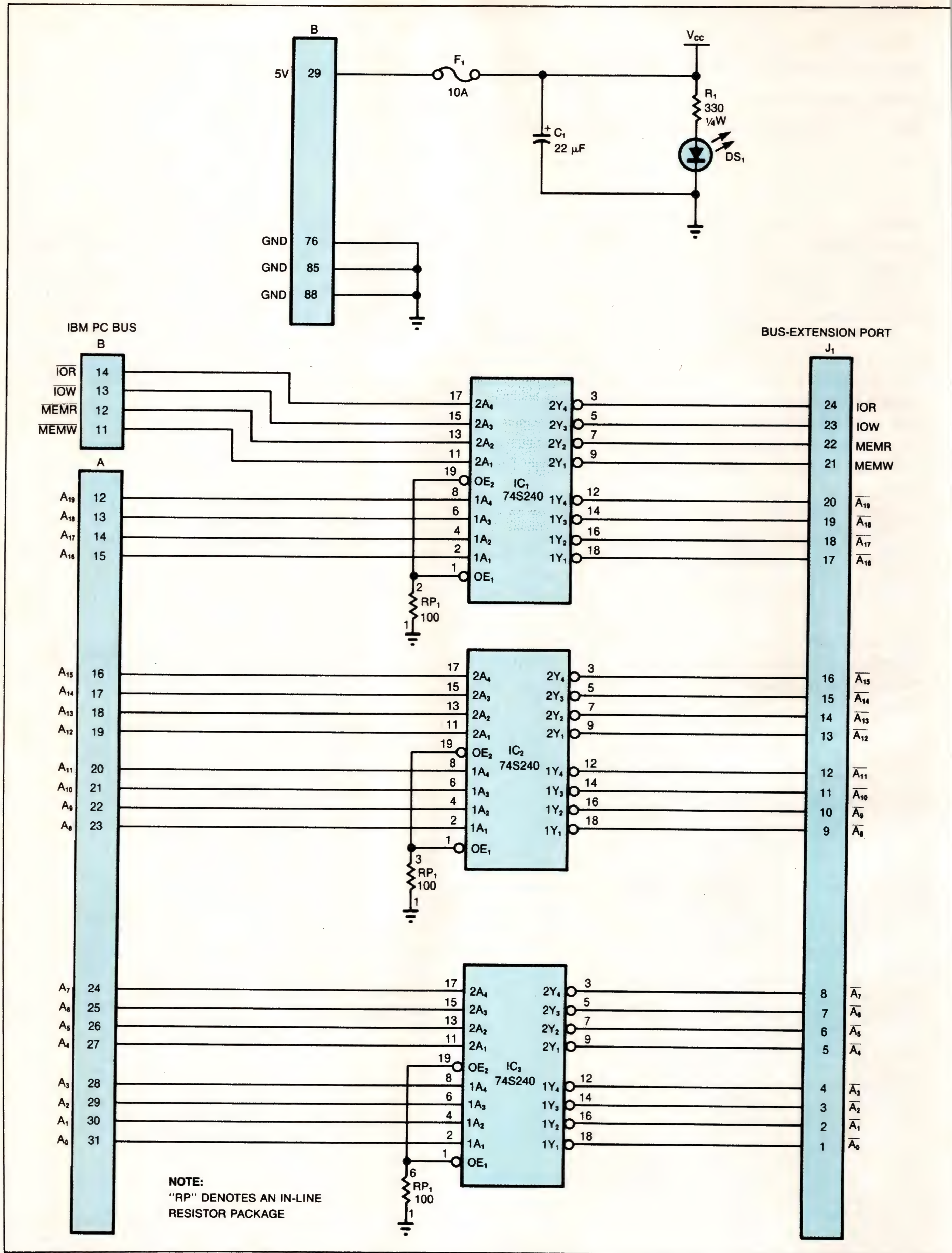
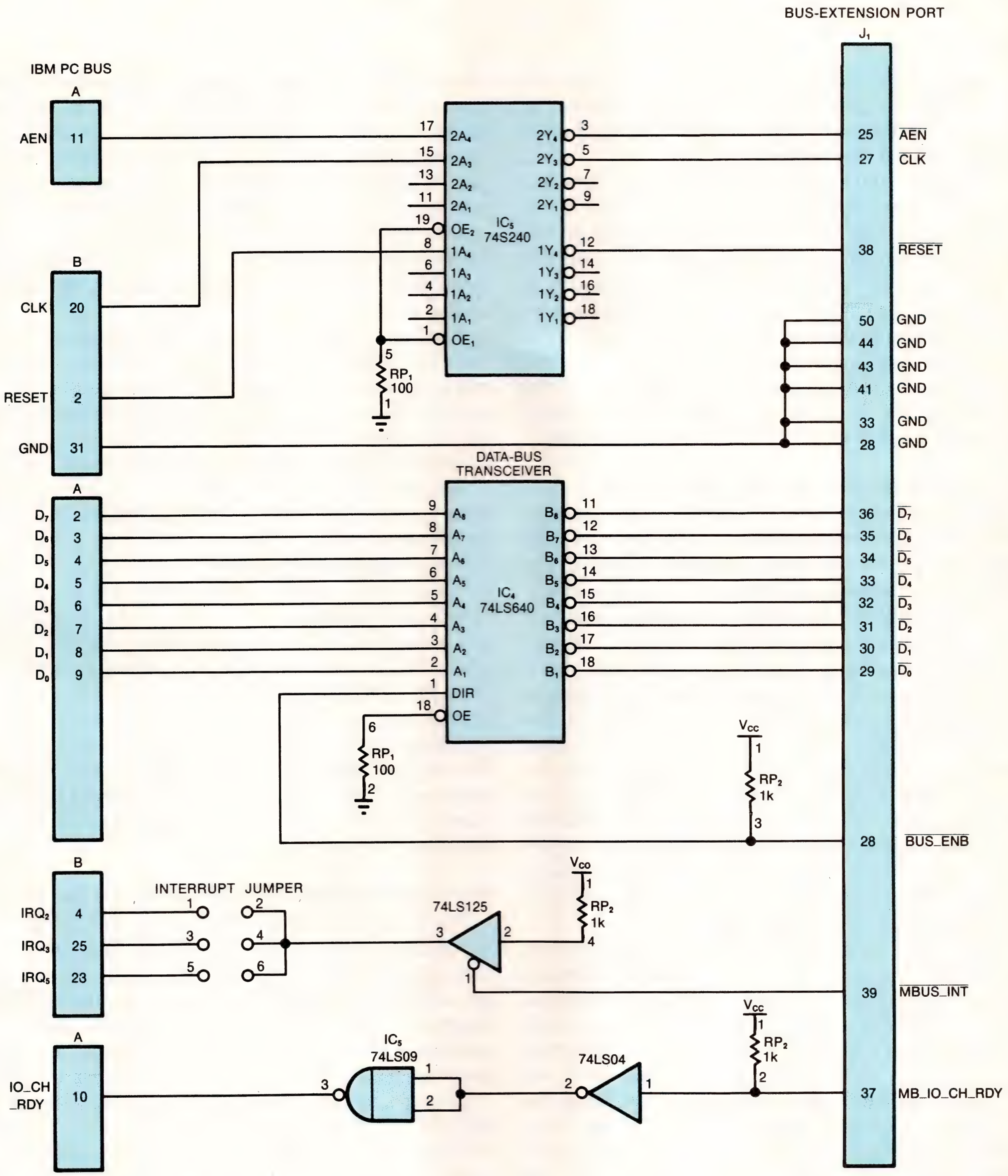


***Fig 3—The PC bus extender consists mainly of line drivers and receivers** that allow you to extend data, address, and control lines by several feet without introducing noise. They also protect the PC against possible damage from malfunctions in the external equipment.*


IBM PC BUS
A
AEN 11
B
CLK 20
RESET 2
GND 31
A
D7 2
D6 3
D5 4
D4 5
D3 6
D2 7
D1 8
D0 9
B
IRQ2 4
IRQ3 25
IRQ5 23
A
IO_CH_RDY 10
IC5 74S240
2A4 2A3 2A2 2A1 OE2 1A4 1A3 1A2 1A1 OE1
2Y4 2Y3 2Y2 2Y1 1Y4 1Y3 1Y2 1Y1
RP1 100
DATA-BUS TRANSCEIVER
IC4 74LS640
A8 A7 A6 A5 A4 A3 A2 A1 DIR OE
B8 B7 B6 B5 B4 B3 B2 B1
RP1 100
VCC
RP2 1k
INTERRUPT JUMPER
74LS125
IC5 74LS09
74LS04
BUS-EXTENSION PORT
J1
25 AEN
27 CLK
38 RESET
50 GND
44 GND
43 GND
41 GND
33 GND
28 GND
36 D7
35 D6
34 D5
33 D4
32 D3
31 D2
30 D1
29 D0
28 BUS_ENB
39 MBUS_INT
37 MB_IO_CH_RDY

The ideal bus converter is completely transparent to the host PC, but the time and cost constraints of such a design may force you to make tradeoffs.

address all of the external memory by adding a memory-page register to the bus-interface logic and by arranging for software routines to load the high-order address bits into this register.

Even if your application does allow you to develop a completely transparent interface, the cost of the necessary hardware and the inconvenience of any special handling techniques may be prohibitive. The tradeoffs you'll have to make will depend on your application as well as on the two buses you're using. Your application will determine the memory and I/O space needed, the mapping of logical to physical addresses, the number of interrupt levels (if any), and the transfer speed. From this information, you'll have to establish the relative costs of interface transparency and special handling.

The Multibus is faster than the IBM PC bus

Before developing your hardware interface, you must consider the architectures of the systems for which each bus is designed. The PC bus has an 8-bit data bus, and it allows you to address as much as 1M byte of memory. However, various sections of the PC's memory map are reserved for special purposes **(Fig 1)**. The PC uses the same data and address lines for I/O transfers, but it decodes only the 10 least significant address lines, so you can address only 1024 I/O locations. Of these, the lower 512 locations are reserved for the PC mother board and can't be used by devices plugged into the expansion-card slots. The upper 512 locations are reserved for devices in the card slots **(Table 1)**. The I/O capabilities of the PC include DMA transfers and interrupt handling. (For complete details of the PC's capabilities and timing requirements, refer to the IBM PC Hardware Technical Reference Manual.)

The Multibus has a 16-bit data bus, and it permits you to address as much as 1M byte of memory. Memory transfers can be byte-wide (as in the PC) or word-wide (16-bit) transfers. The address lines are common to both I/O- and memory-transfer operations, but Multibus systems decode 16 bits of an I/O address, so 65,536 locations are available. The timing requirements of the Multibus are relatively simple and present few problems when you're interfacing the Multibus to the slower PC bus. (Refer to the Intel Multibus Specification for complete details of the Multibus.)

The PC-to-Multibus hardware interface described in this article is transparent to the host system (the PC). It can address any memory locations on the Multibus that are not already resident on or reserved by the PC. (In this implementation, PC addresses 80000_{HEX} through $9FFFF_{HEX}$ are available.) The interface circuitry converts these logical memory addresses to physical Multibus addresses. However, memory addresses must be remapped on 64k-byte boundaries only. For example, if you have two separate 64k-byte blocks (or a contiguous block of 128k bytes) of unused memory space in the PC, you can dedicate this space as logical address space for the Multibus memory. Each such block must start on a 64k-byte boundary (an address ending in 0000_{HEX}).

Memory transfers take place one byte at a time. You can use the full 16-bit Multibus I/O address space, and you can remap any unused PC I/O address location to any Multibus I/O location you wish; you are limited only by the number of free PC I/O address locations. I/O data transfers are also performed one byte at a time.

The interface circuitry allows you to use all of the eight levels of non-bus-vectored interrupts permitted by the Multibus, but it doesn't provide for DMA transfers or multiple bus masters. The complete interface consists of two boards connected by a ribbon cable. One board, the PC bus extender, is responsible for buffering and isolating all PC bus signals passing over the ribbon cable. The other board is the PC/Multibus converter **(Fig 2)**. The PC bus extender resides in the PC's chassis, and the PC/Multibus converter resides in the Multibus chassis. Dividing up the conversion system in this manner allows you to connect a single, general-purpose PC bus extender to converters for a variety of buses without making any changes to the PC bus extender.

Remap memory and I/O addresses separately

The PC bus-extender circuitry **(Fig 3)** is simple; the PC/Multibus converter circuitry **(Fig 4)** is more complex. All the lines carrying signals from the extender are terminated by pullup resistors located in in-line resistor packages (RPs), which reduce noise. Addresses generated by the PC, and buffered in the extender, enter the converter on lines $\overline{ADDR_{0-13}}$ at connector J_1.

During a memory access, the upper four bits of the address are applied to four inputs of IC_4, a look-up PROM **(Fig 5)**. This PROM contains a look-up table that remaps the logical PC memory address for a 64k-byte segment to the appropriate physical Multibus address. The lower 16 bits of the address remain unchanged. For example, to remap memory addresses $A0000_{HEX}$ through $AFFFF_{HEX}$ on the PC to $E0000_{HEX}$ through $EFFFF_{HEX}$ on the Multibus, the PROM simply remaps segment A_{HEX} to E_{HEX}. This scheme keeps the circuitry

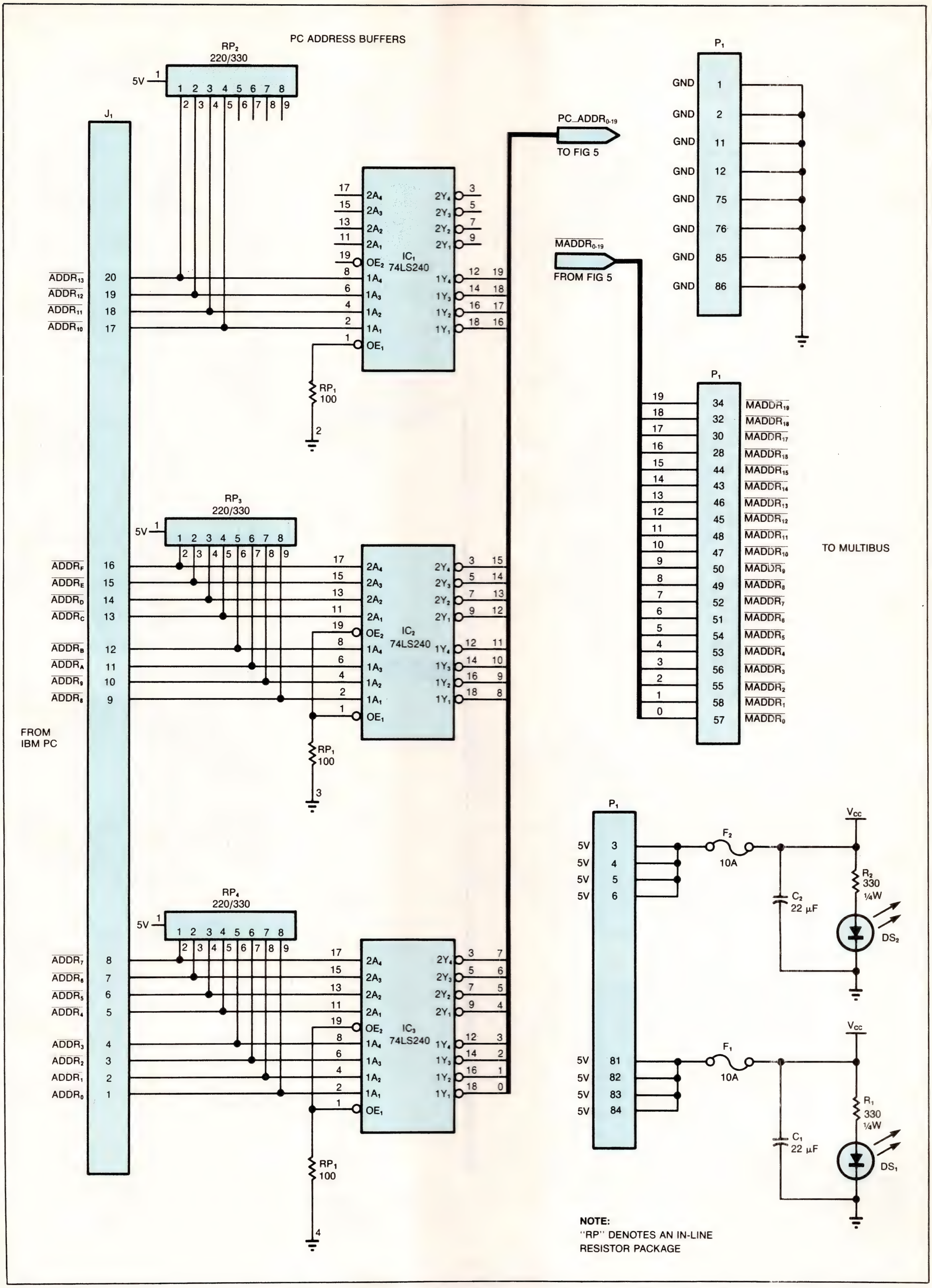
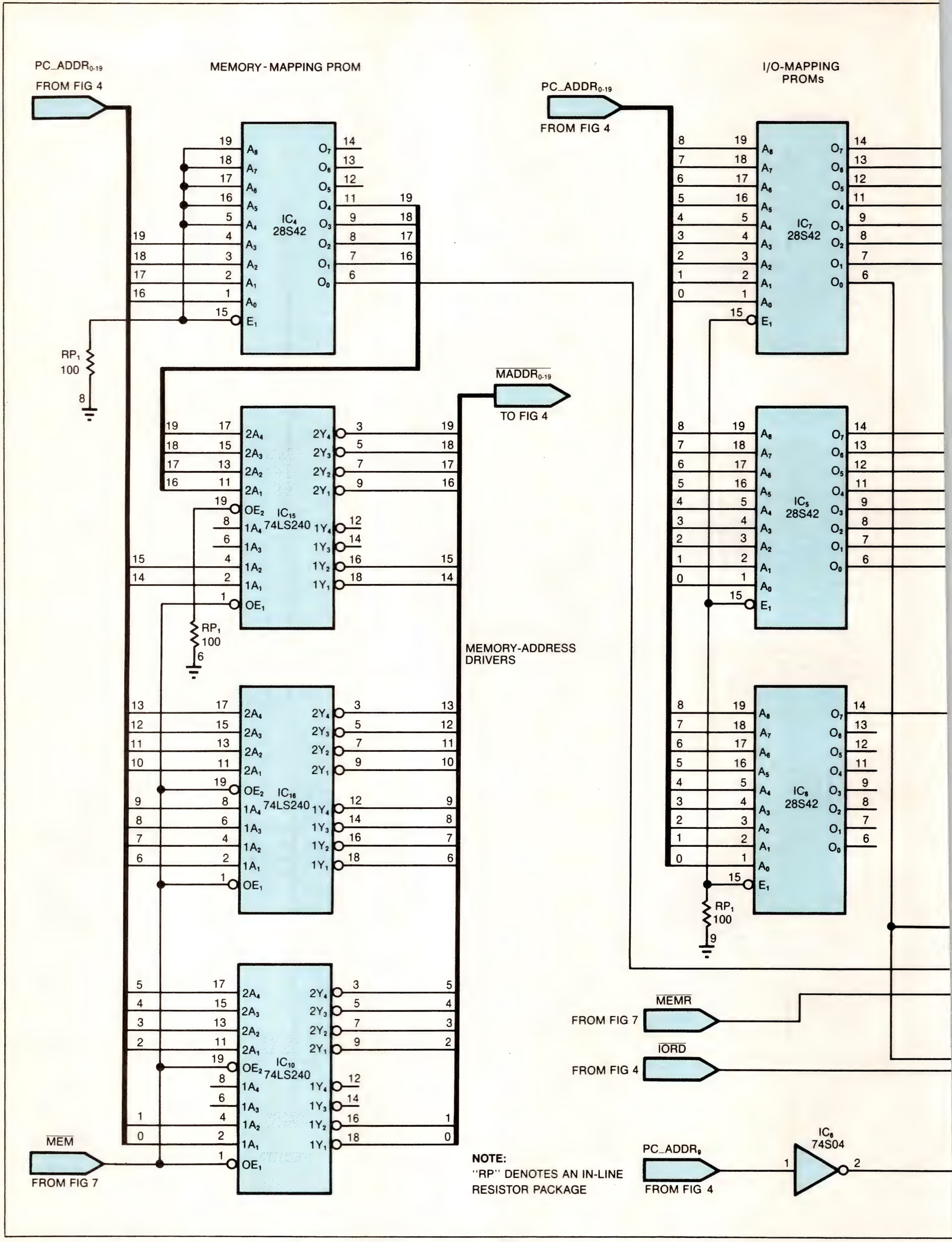
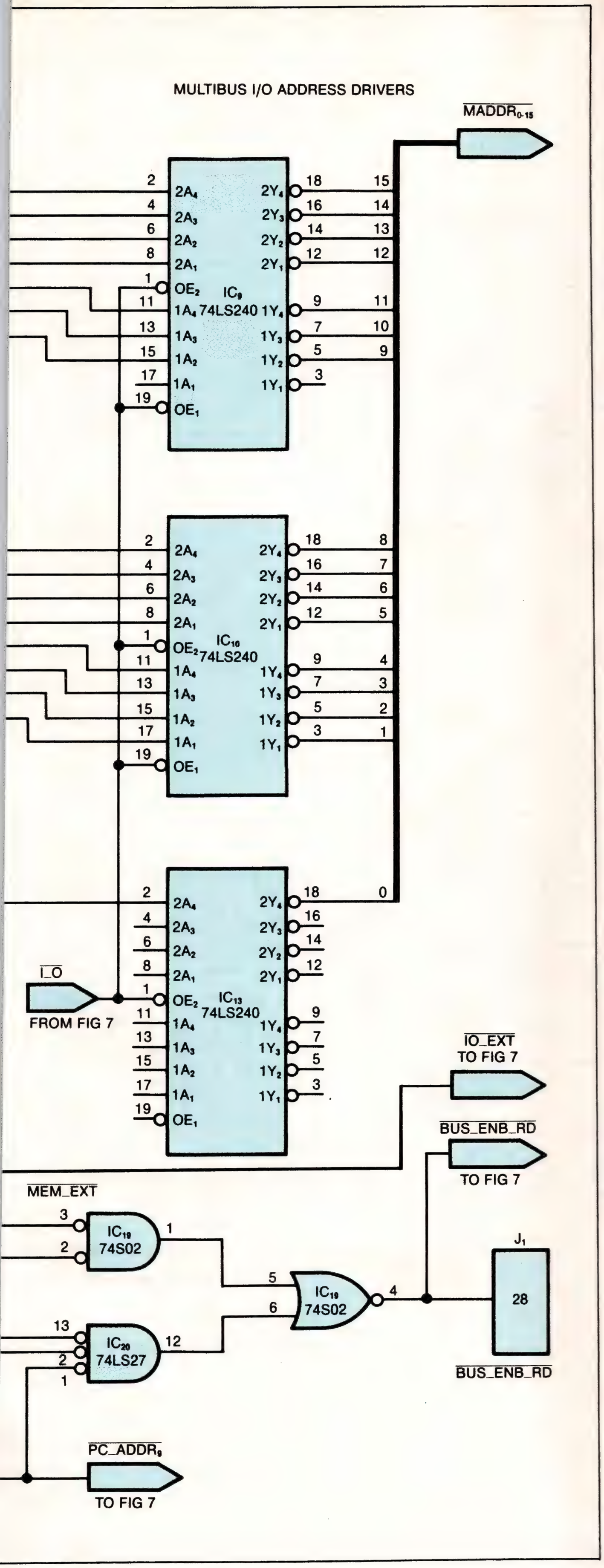


***Fig 4—The PC/Multibus converter buffers and terminates all signals** that enter and leave it by way of the ribbon cable.*



NOTE:
"RP" DENOTES AN IN-LINE
RESISTOR PACKAGE

Fig 5—The PC/Multibus converter remaps memory and I/O addresses separately *before passing them to the Multibus equipment. IC_4 remaps memory addresses in blocks of 64k bytes. IC_5, IC_7, and IC_8 generate a 16-bit Multibus I/O address from a 9-bit PC I/O address.*



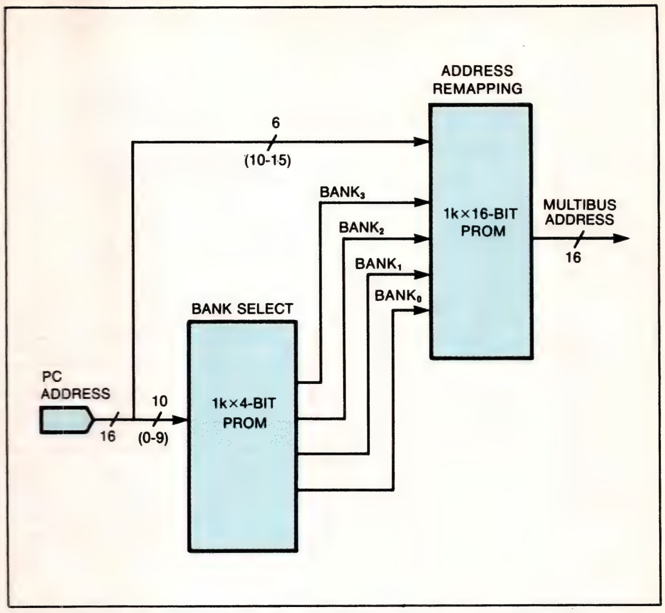


Fig 6—You can expand the Multibus address space *by using a single PC I/O location to select one of several banks of Multibus I/O addresses, into which you can remap standard PC I/O addresses.*

simple. If you want to remap areas smaller than 64k bytes, you'll have to present more address lines to the look-up PROM.

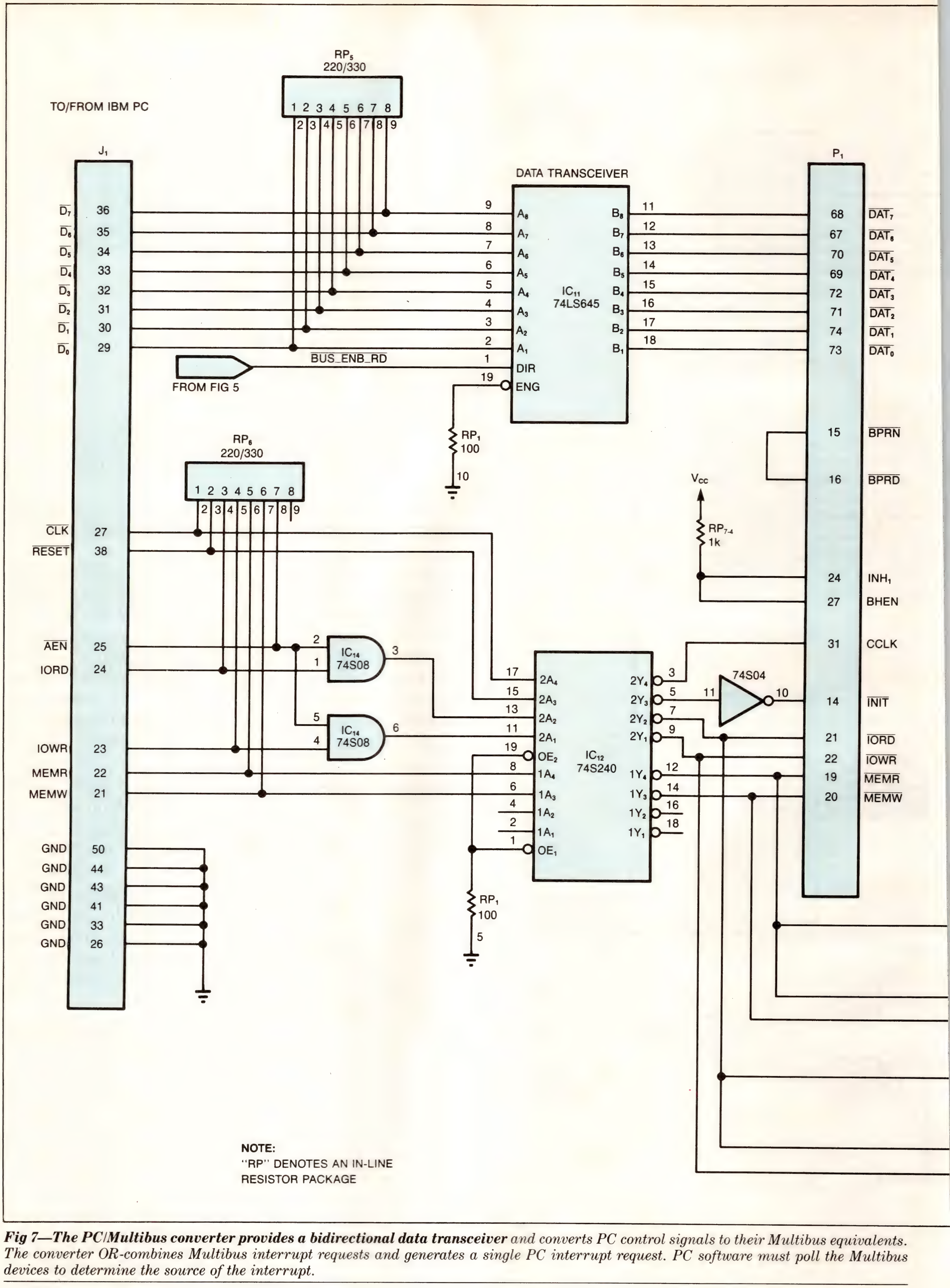
During an I/O access, the buffered PC address that appears on lines $PC\_ADDR_{0\text{-}8}$ is remapped to a physical Multibus address by I/O-mapping PROMs IC_5, IC_7, and IC_8. To ensure that this 9-bit address (which corresponds to one of the 512 PC I/O locations) is a valid off-board I/O location, you gate the address with PC_ADDR_9. This method allows you to remap any unused PC I/O address to any Multibus I/O address.

For example, during an I/O write operation, the PC address enters the I/O-mapping PROMs. The PROM location corresponding to the PC address contains the Multibus address. You need three PROMs in order to obtain the full 16-bit Multibus I/O address and the $\overline{IO\_EXT}$ signal. The $\overline{IO\_EXT}$ signal indicates that the current address is to be remapped to a Multibus address. You perform this remapping by simply programming the PROM with a zero in every location that corresponds to an address to be remapped. You should program the PROMs to generate an unused address (for example, $FFFF_{HEX}$) whenever the address presented to the remapping PROMs is not valid.

If your application requires more I/O space than the PC can provide, you'll need to expand the PC's I/O space by using the six remaining high-order address bits (bits 10 to 15) and one or more of the unused locations within the I/O space. This scheme allows each unused I/O location to select a bank of 64 extended I/O addresses. The high-order address bits select a location within the bank. **Fig 6** shows how to add 256 Multibus I/O locations by using four unused PC I/O locations.

The PC/Multibus converter provides two sets of Multibus address drivers: memory-address drivers and I/O-address drivers. In the converter, IC_{14} gates the IORD and IOWR signals with $\overline{AEN}$ (**Fig 7**). When a

Text continued on pg 178



NOTE:
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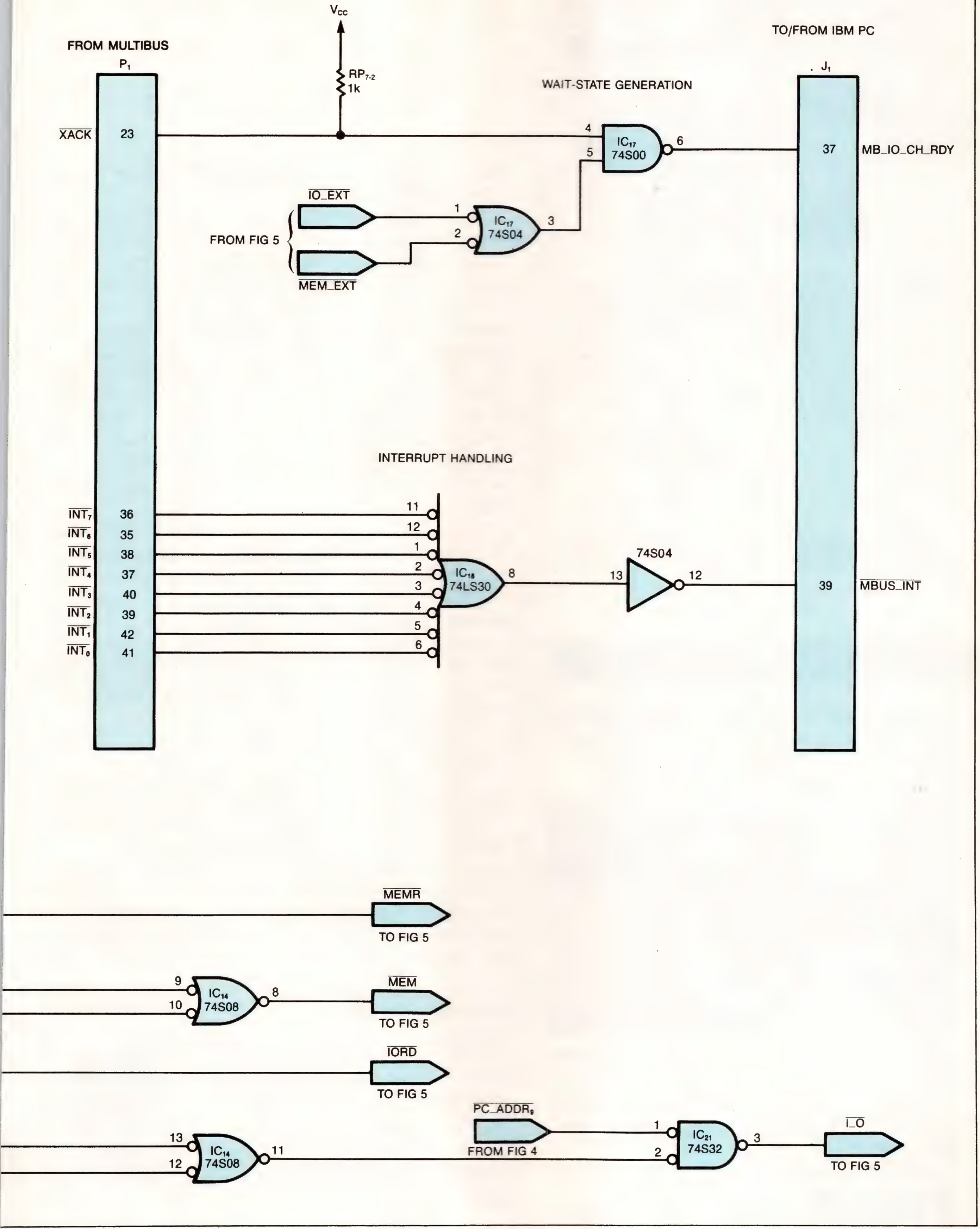
Fig 7—The PC/Multibus converter provides a bidirectional data transceiver *and converts PC control signals to their Multibus equivalents. The converter OR-combines Multibus interrupt requests and generates a single PC interrupt request. PC software must poll the Multibus devices to determine the source of the interrupt.*


FROM MULTIBUS
P_1
V_{CC}
$RP_{7\text{-}2}$ 1k
TO/FROM IBM PC
J_1
WAIT-STATE GENERATION
$\overline{XACK}$ 23
4
5
IC_{17} 74S00
6
37 MB_IO_CH_RDY
$\overline{IO\_EXT}$
FROM FIG 5
$\overline{MEM\_EXT}$
1
2
IC_{17} 74S04
3
INTERRUPT HANDLING
$\overline{INT_7}$ 36
$\overline{INT_6}$ 35
$\overline{INT_5}$ 38
$\overline{INT_4}$ 37
$\overline{INT_3}$ 40
$\overline{INT_2}$ 39
$\overline{INT_1}$ 42
$\overline{INT_0}$ 41
11
12
1
2
3
4
5
6
IC_{18} 74LS30
8
74S04
13
12
39 $\overline{MBUS\_INT}$
$\overline{MEMR}$
TO FIG 5
9
10
IC_{14} 74S08
8
$\overline{MEM}$
TO FIG 5
$\overline{IORD}$
TO FIG 5
$\overline{PC\_ADDR_9}$
FROM FIG 4
13
12
IC_{14} 74S08
11
1
2
IC_{21} 74S32
3
$\overline{I\_O}$
TO FIG 5

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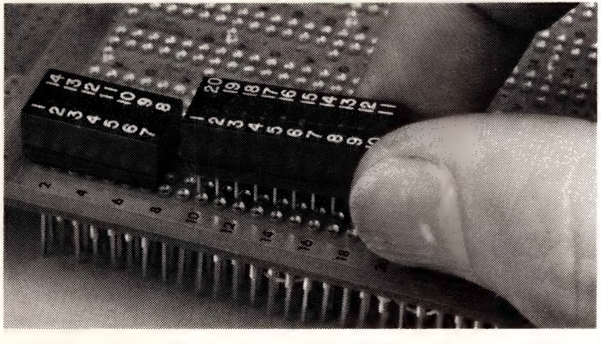

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CIRCLE NO 115

DMA operation is in progress, $\overline{\text{AEN}}$ goes active and disables IORD and IOWR.

Your hardware interface must be capable of recognizing a read access to the Multibus, so that it can enable the data-bus drivers (IC_{11} on the converter and IC_4 on the extender). The address-mapping PROMs recognize accesses to the Multibus. These PROMs are programmed to remap valid addresses and generate an active-low address-valid signal, $\overline{\text{MEM\_EXT}}$ or $\overline{\text{IO\_EXT}}$. During an I/O read for example, the signal $\overline{\text{IO\_EXT}}$ goes low, PC address bit 9 is high, and $\overline{\text{IORD}}$ is low, indicating an I/O read from the Multibus. IC_{20} **(Fig 5)** combines these signals to reverse the data path through IC_{11} **(Fig 7)** by setting $\overline{\text{BUS\_ENB\_RD}}$ low, and thus drives data from the Multibus onto the PC bus.

IC_{18} **(Fig 7)** combines signals from any of the eight Multibus interrupt lines; you should connect the resultant $\overline{\text{MBUS\_INT}}$ signal to an unused PC interrupt-request channel, such as IRQ_2, by means of the jumper pads on the extender board **(Fig 3)**. When a Multibus interrupt occurs, it generates an interrupt request to the PC. The PC can determine the source of the interrupt by querying each interrupting device on the Multibus.

The Multibus transfer-acknowledge signal, $\overline{\text{XACK}}$, controls the PC I/O-channel-ready signal (IO_CH_RDY) for slow data transfers. During any Multibus transfer, $\overline{\text{XACK}}$ is driven high when the transfer cycle begins. When the transfer is complete, $\overline{\text{XACK}}$ goes low and remains low until the I/O or memory read/write signal is released. $\overline{\text{XACK}}$ then returns high. To interface $\overline{\text{XACK}}$ to the PC, you hold IO_CH_RDY low on a Multibus transfer while $\overline{\text{XACK}}$ is high, thereby adding PC wait states until $\overline{\text{XACK}}$ goes low, which indicates that the transfer is complete. **EDN**

Author's biography

Bill Robertson is a member of the technical staff at KLA Instruments Corp, where he is responsible for the development of hardware for reticle-inspection equipment. Bill, who holds a BSEE from the University of California at Davis, is a member of the IEEE. In his spare time he enjoys running, weight lifting, racquetball, and basketball.

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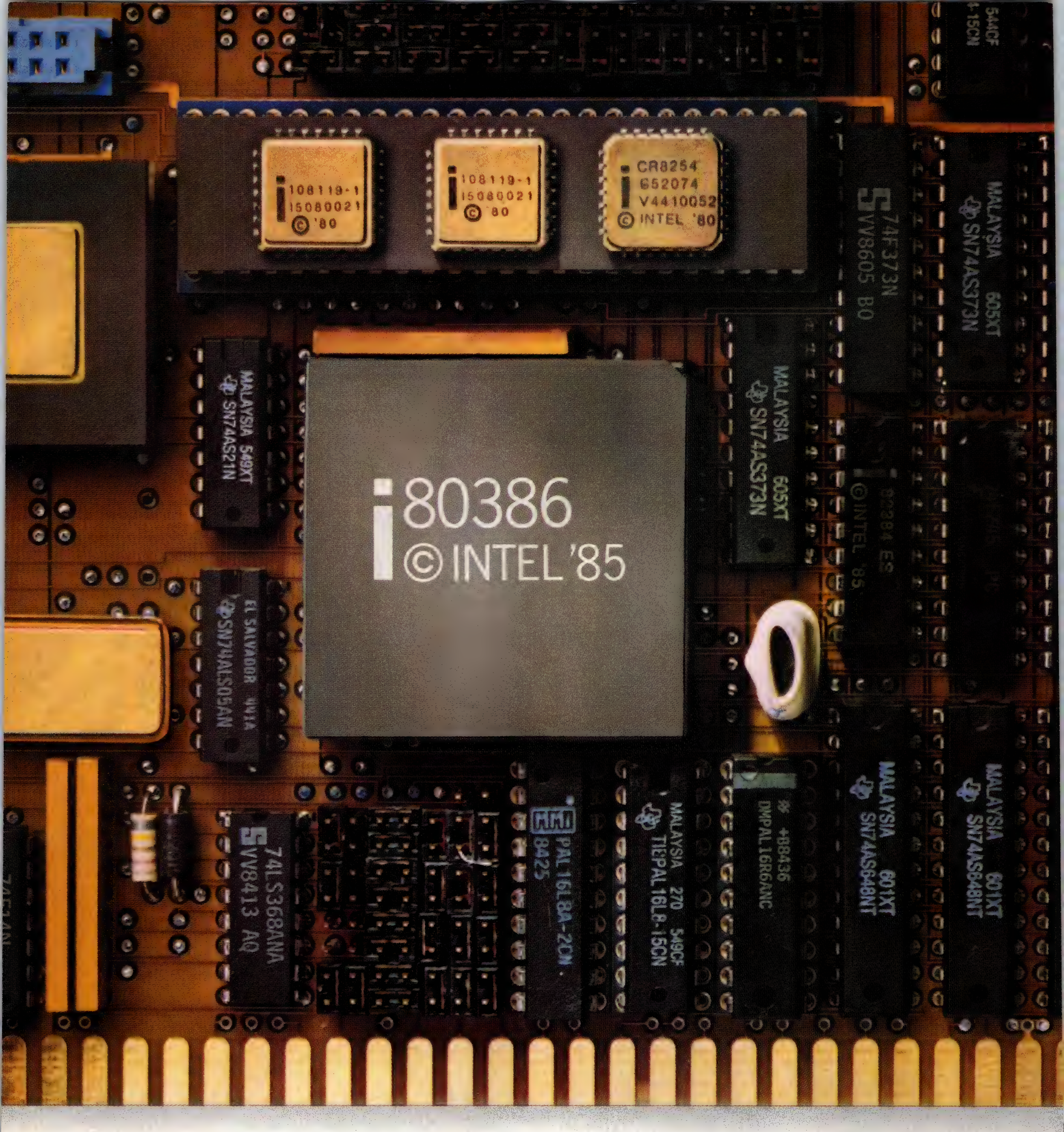

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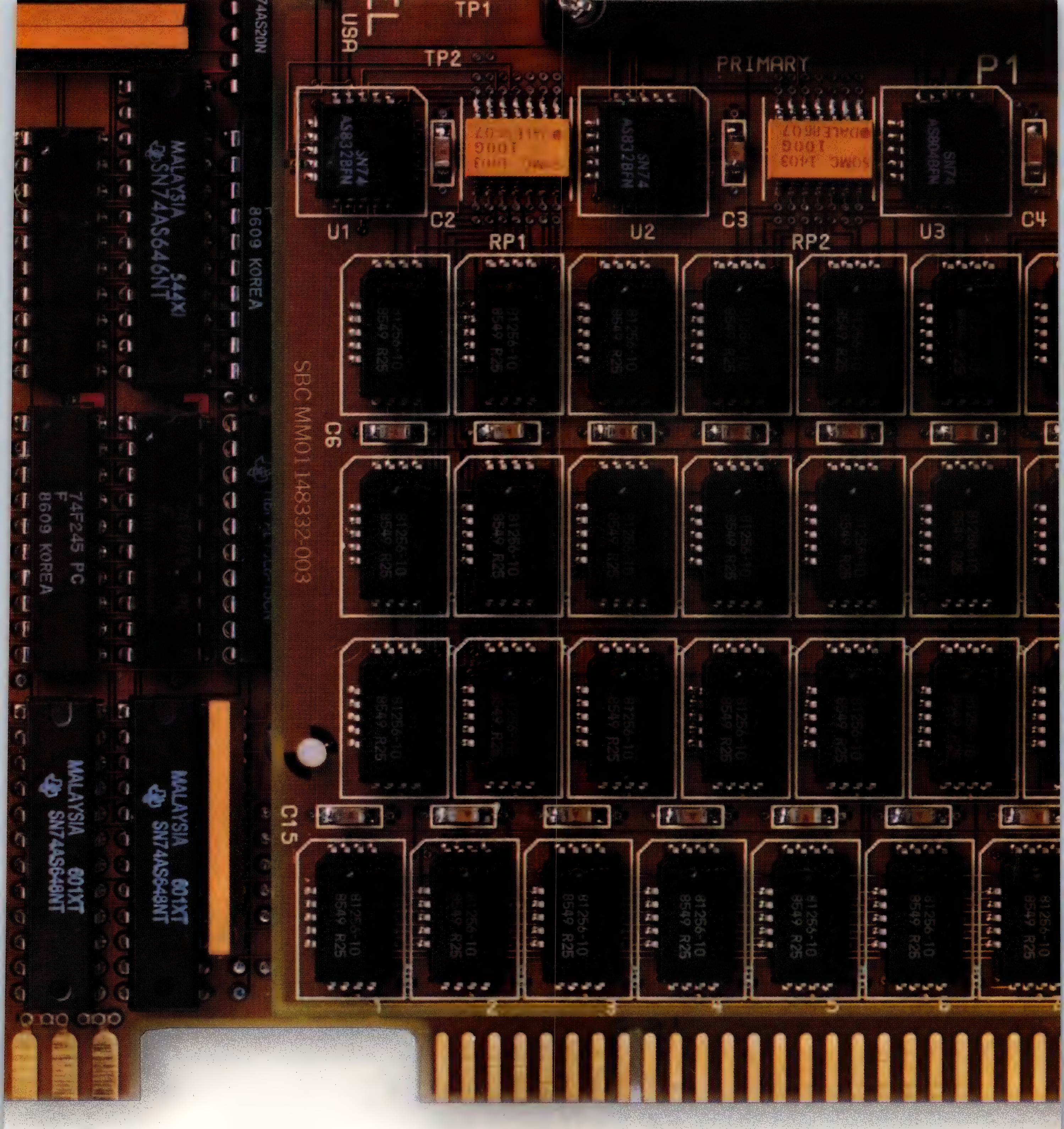

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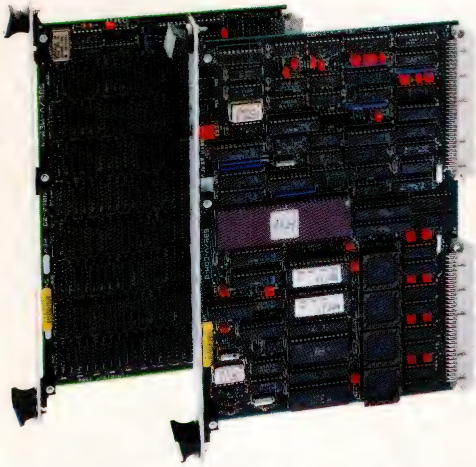

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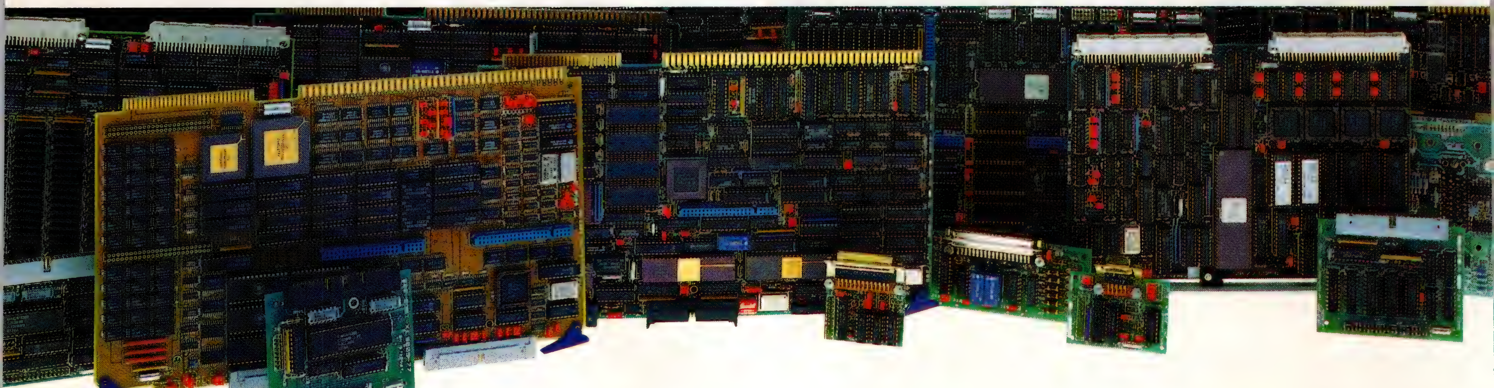

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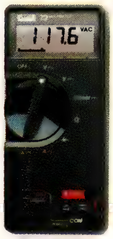

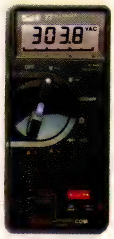

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CIRCLE NO 119

Low-power op amp delivers precision at low signal levels

Single-supply and battery-powered designs often have high signal impedances and low signal voltages, so they demand low input currents and precision amplification. To obtain precise performance in your low-power circuits, you can use an op amp that draws 15 μA of quiescent current.

Derek F Bowers, Art Kapoor, and Andrew Jenkins, *Precision Monolithics Inc*

Systems that operate from low supply current and voltages, such as single-supply and battery-powered systems, often have high signal impedances and demand low input currents. These circuits also tend to have low signal voltages (and therefore a reduced dynamic range), so they require op amps with good dc parameters. The examples that follow demonstrate the techniques involved in implementing such circuits and others; they make use of the OP-90 low-power op amp to implement a battery-powered voltage reference, an instrumentation amplifier, a single-supply current monitor, a fully floating 4- to 20-mA transmitter suitable for industrial-control systems, a full-wave rectifier, and a precision voltage-controlled oscillator (VCO).

Battery applications

Fig 1 shows how you can use the OP-90 (see **box,** "The OP-90 low-power op amp") in an accurate, battery-powered voltage reference that uses the bandgap technique. Two AA cells can power this design for more than 18 months, because it draws only 17 μA of supply current.

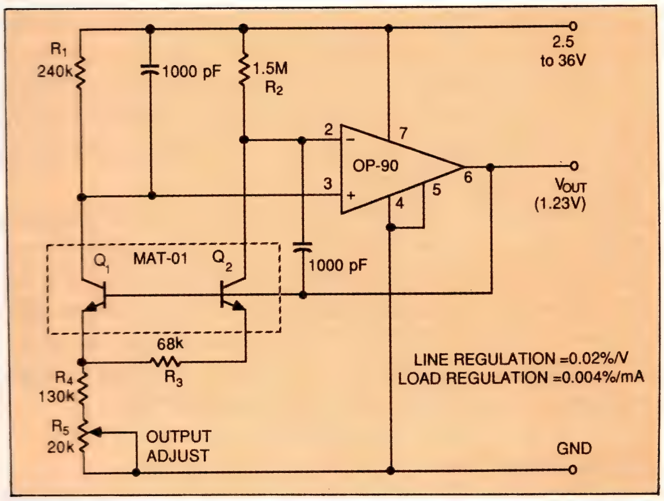


***Fig 1—This accurate, battery-powered voltage** reference uses the bandgap technique. Two AA penlight cells can power it for more than 18 months because it draws only 17 μA of supply current.*

Note that the OP-90, with its 1.6V minimum supply voltage, can't operate from a single, nearly discharged dry cell. However, it can operate from a lithium cell. **Fig 2** shows the typical discharge characteristics of a 1-Ahr lithium cell that's powering an OP-90, which in turn is driving a full voltage swing into a 100-kΩ load.

Scaling resistors R_1 and R_2 produce asymmetrical currents in Q_1 and Q_2. The resulting V_{BE} mismatch creates a temperature-proportional voltage across R_3 which, in turn, produces a larger, temperature-proportional voltage across R_4 and R_5. This voltage appears at the circuit's output, where it's added to the V_{BE} of Q_1. The temperature coefficients of Q_1's V_{BE} and of the voltage across R_4 and R_5 are opposites, so they cancel each other.

Adjusting the output to 1.23V theoretically produces minimum drift—about 20 ppm/°C over the commercial temperature range. You can obtain much lower drift by tailoring the output voltage for each individual MAT-01.

> *An instrumentation amplifier whose input and output range include the negative supply suits thermocouple or strain-gauge amplification in noisy environments.*

A 1% change in output voltage produces a predictable 33-ppm/°C drift.

Avoiding start-up problems

Designs employing feedback as does **Fig 1**'s circuit frequently have start-up problems. When no current is flowing through R_1 and R_2, the amplifier is beyond its positive input-range limit and has an undefined output state. To ensure reliable start-ups, you can short pin 5 (an offset-adjust pin) to ground, thus forcing the output high at power-up.

Fig 3 shows an unusual approach to an instrumentation amplifier whose input and output range include the negative supply. Such an amplifier is suitable for thermocouple or strain-gauge amplification in noisy environments. Feedback goes to the null pins rather than to the inverting input, freeing up both sides of the input stage for signal handling.

The amplifier's distortion is that of a differential pair, so the design is restricted to high-gain applications—linearity is about 0.05% at a gain of 1000 over a 2.5V output range. Resistors R_3 and R_4 set the voltage gain and accommodate tolerance variations in the op amp's internal resistors. The op amp's biasing yields a gain temperature coefficient of about 50 ppm/°C.

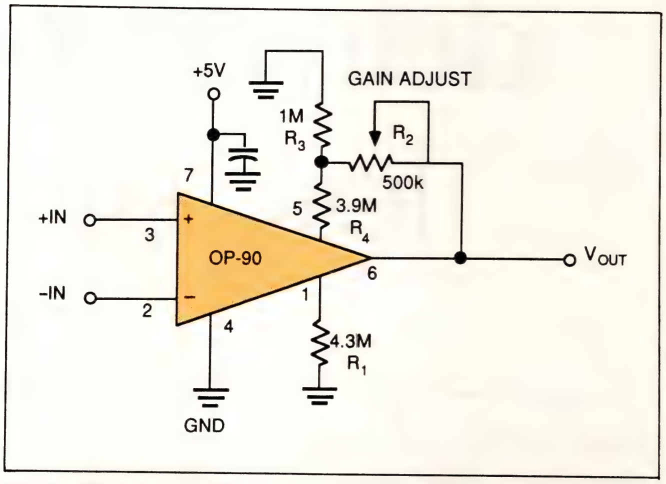


*Fig 3—**This unusual instrumentation amplifier** has an input and output range that includes the negative supply. Feedback goes to the null pins rather than to the inverting input, so both sides of the input stage are free for signal handling.*

Current monitor

Amplifying the voltage drop across a resistor placed in series with the current to be measured is the technique used by most current-monitoring circuits. The major problem facing current-monitor designers is that the circuits being monitored can tolerate only small voltage drops. If you use low-precision op amps in a current monitor, the small voltage drop from the circuit under test greatly limits the current monitor's overall resolution.

Fig 4 shows a single-supply current monitor that's capable of monitoring 30 mA with a resolution of about 10 μA. You can easily alter this range by changing R_1. Some applications might require that the supply current of the current monitor itself be included in the result—something that doesn't happen automatically because the current from pin 4 doesn't flow through R_1.

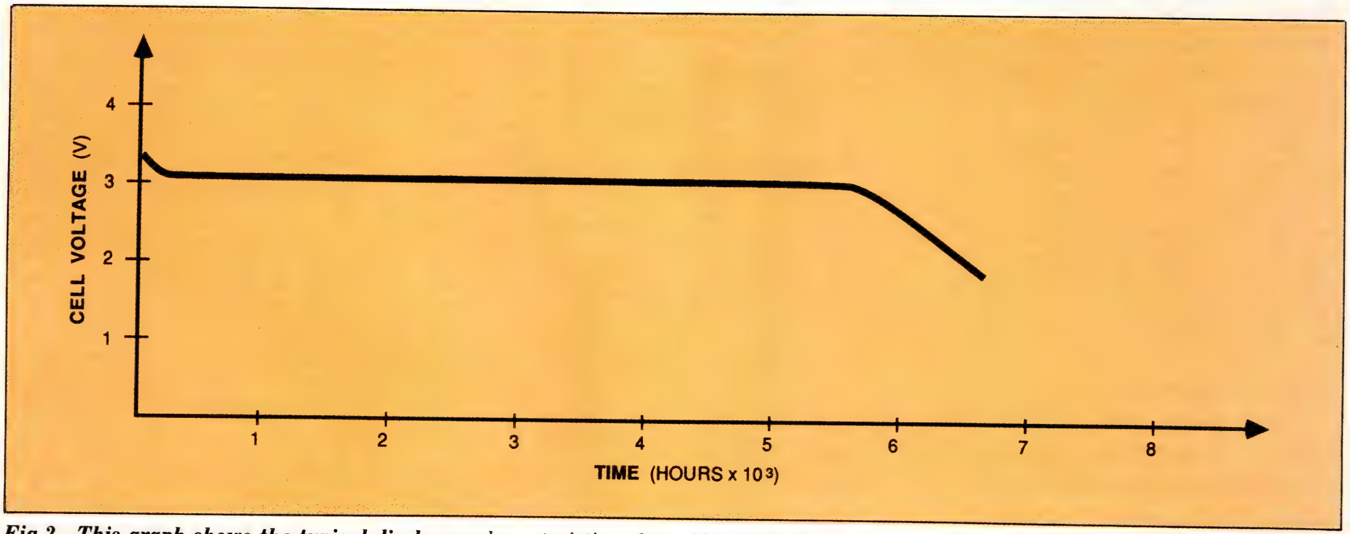


*Fig 2—**This graph shows the typical discharge** characteristics of a 1-Ahr lithium cell powering an OP-90, which in turn is driving a full voltage swing into a 100-kΩ load.*

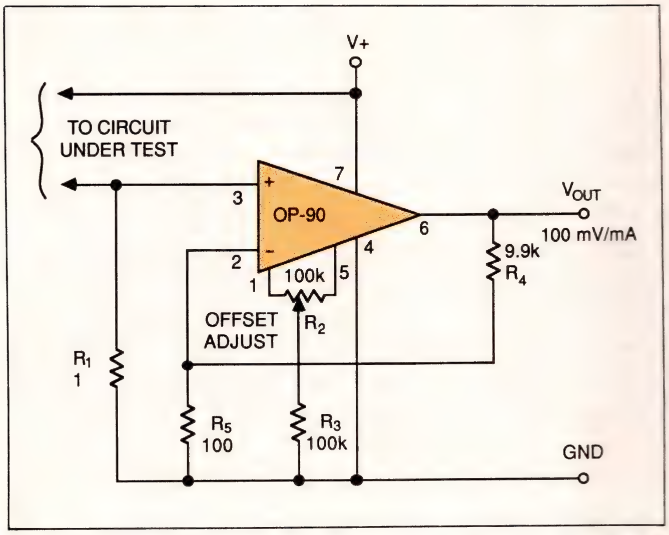


Fig 4—This single-supply current monitor can monitor 30 mA with a resolution of about 10 μA. You can easily alter this range by changing R_1.

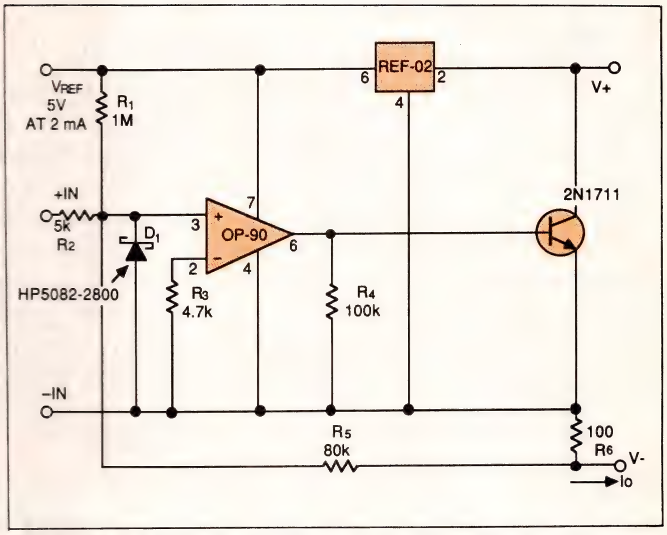


Fig 5—This fully floating 4- to 20-mA transmitter suits industrial-control systems. The REF-02 provides the 4-mA offset and also supplies as much as 2 mA for transducer excitation.

You can measure this current and calibrate the circuit (together with the residual offset) by adjusting R_2.

Temperature effects cancel

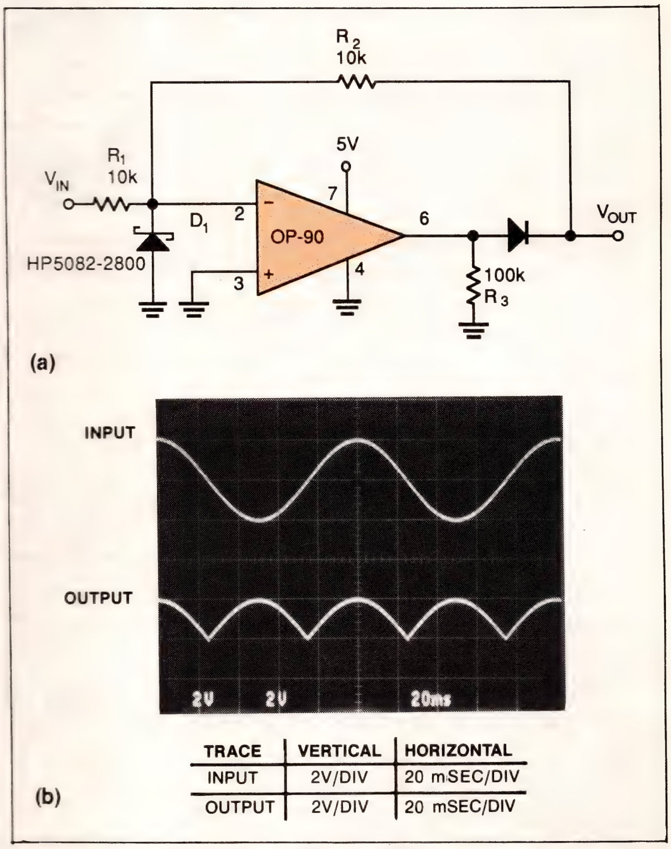
Such an adjustment produces a deliberate V_{OS} in the OP-90's output that is temperature dependent (as is the case for most precision op amps). However, the supply current of the OP-90 is also approximately proportional to temperature, and the two effects tend to track. A gain trim can account for current in R_4 and R_5 (which also bypasses R_1). Note that R_3 has been placed in series with the wiper of R_2. This resistor (R_3) reduces the offset-adjust range from 6 mV to about 400 μV, and is recommended for applications requiring high null resolution.

Fully floating 4- to 20-mA transmitter

The OP-90's ability to operate in the single-supply mode opens up some unusual applications possibilities, such as the fully floating 4- to 20-mA transmitter in **Fig 5**. The circuit is suitable for industrial-control systems.

The REF-02 provides the 4-mA offset and also supplies as much as 2 mA for transducer excitation. If necessary, you can adjust R_1 to effect an offset trim, and you can adjust R_2 to effect a gain trim. These trims will not interact, because the noninverting input of the OP-90 is at virtual ground.

The Schottky diode, D_1, is not necessary for circuit operation, but it prevents glitches from pulling the noninverting input more than 300 mV below ground.



TRACE	VERTICAL	HORIZONTAL
INPUT	2V/DIV	20 mSEC/DIV
OUTPUT	2V/DIV	20 mSEC/DIV

Fig 6—This circuit develops the absolute value of input signals as high as ±2.5V, even though it operates from a single 5V supply. The scope photo shows the circuit's performance with 4V p-p input at 10 Hz.

The major problem facing current-monitor designers is that the circuits being monitored can tolerate only small voltage drops.

The OP-90 single-supply op amp

For single-supply and battery-powered systems, consider using an ultra-low-power op amp such as the OP-90 (**Fig A**), which operates from a single supply and is compatible with a number of available batteries, yet provides good dc performance. The op amp draws only 15 µA of quiescent current; its input offset voltage is 150 µV max, its CMRR is 100 dB min, and its open-loop gain is 700,000V/V min. However, the op amp does sacrifice slew rate in order to operate from low power. **Table 1** lists the salient specs for the OP-90.

Output stage

The OP-90 has a class AB output stage that reverts to a simple emitter-follower as inputs approach ground. This reversion makes possible a guaranteed swing within 500 µV of ground when the op amp is driving a 10-kΩ load. One hazard of this scheme is that the output impedance of the output transistor (Q_{13}) approaches infinity as the output approaches ground.

Under these conditions, stray capacitance at the output could cause severe loss of phase margin and possible oscillation. C_4 solves this problem by providing bypass around the output transistor.

Instead of using a Darlington configuration in the input stage (an arrangement that wastes voltage headroom and results in increased drift and noise), the OP-90 uses just a pair of pnp transistors (Q_1 and Q_2). Because it drops only 80 mV across the load resistors, the op amp can operate from a single supply. A foldback-cascode load (Q_7 and Q_8) follows these resistors, so the stage gain is very high.

The high breakdown voltage of the pnp input transistors, coupled with protection resistors R_1 and R_2, allows the inputs to swing 20V beyond either supply rail without damaging the amplifier.

Because fewer transistor base-emitter junctions are required to bias the OP-90 than to bias ordinary op amps, the OP-90 can operate from a very low voltage. For example, the complementary Darlington pair formed by Q_9 and Q_{10} subtracts one full V_{BE} drop less than does a conventional Darlington pair. The op amp draws only 15 µA of quiescent current.

TABLE 1—SALIENT SPECS FOR THE OP-90 OP AMP

SINGLE/DUAL-SUPPLY OPERATION	1.6 TO 36V OR ±0.8 TO ±18V
SUPPLY CURRENT	20 µA MAX
OUTPUT SWING	0 TO 4.2V (V_S=5V)
V_{OS}	150 µV MAX
I_B	15 nA MAX
A_{VO}	700V / mV MIN
CMRR	100 dB MIN
OUTPUT DRIVE	±5 mA MIN (V_S=±15V)
SLEW RATE	8V/mSEC

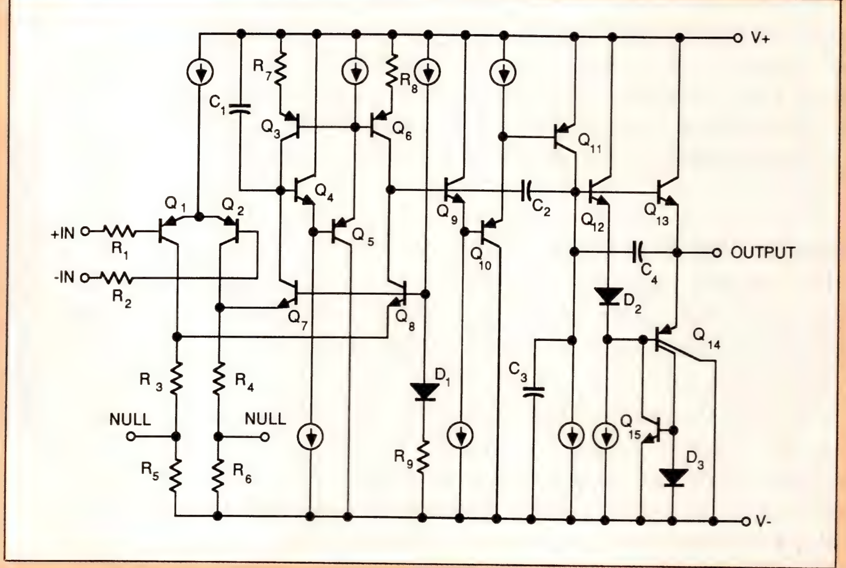


***Fig A—The OP-90 has a class AB** output stage, which reverts to a simple emitter-follower as inputs approach ground. This reversion makes possible a guaranteed swing within 500 µV of ground when the op amp is driving a 10-kΩ load.*

Without this protection, such glitches could cause phase reversal in the OP-90, and they could possibly cause latch-up of the transmitter. This circuit has a 10 to 40V compliance voltage. Its linearity measures about 0.002%, and its line rejection is 0.002%/V.

Unusual rectifier

Fig 6a shows an unusual approach to full-wave rectification. This circuit develops the absolute value of input signals as high as ±2.5V even though it operates from a single 5V supply.

For negative inputs, the amplifier behaves as a unity-gain inverter. Positive inputs send the op amp into negative saturation, and the signal passes directly to the output through R_1 and R_2. Because the output impedance depends on the input's polarity, load impedances produce asymmetry at the output. You can correct this asymmetry by reducing R_2 or by using a second op amp to buffer unpredictable or heavy loads. **Fig 6b** shows the circuit's performance with 4V p-p input at 10 Hz.

The precision VCO shown in **Fig 7** comprises two

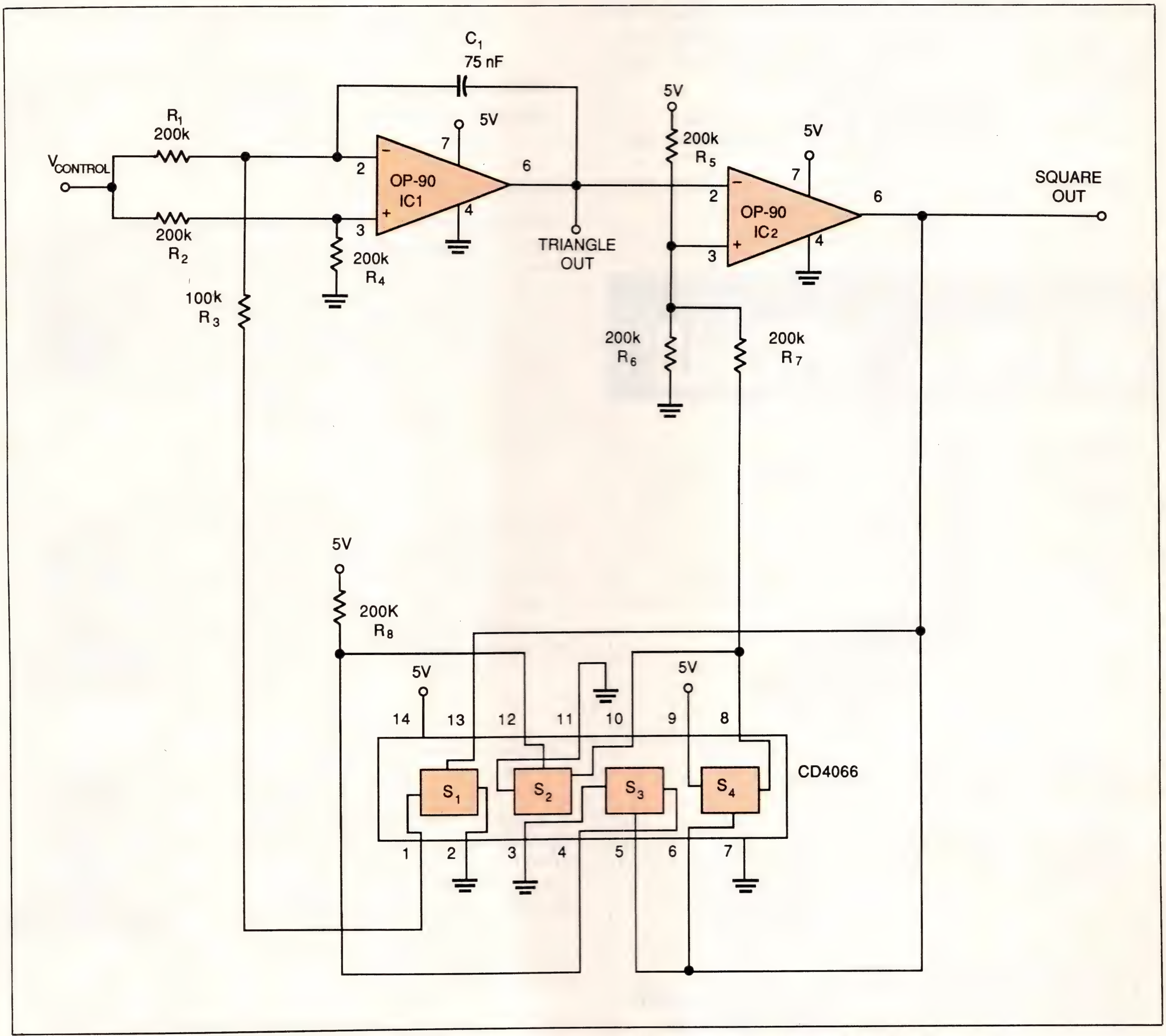
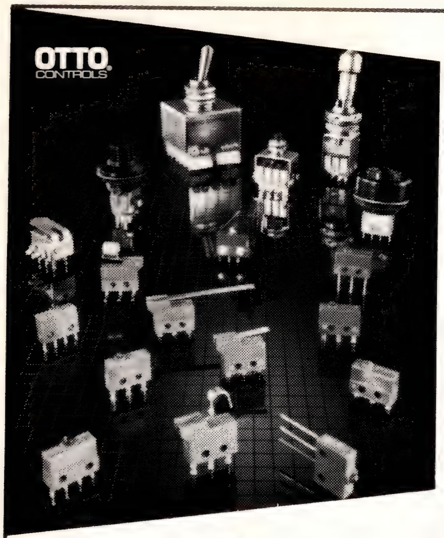


Fig 7— This circuit provides simultaneous triangle and square waves while drawing 50 μA from a single 5V supply.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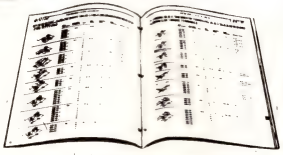
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OP-90s in combination with an inexpensive quad CMOS switch. This circuit provides simultaneous triangle and square waves while drawing 50 μA from a single 5V supply. IC_1 acts as an integrator; S_1 switches the charging current symmetrically to yield positive and negative ramps. IC_2, which acts as a Schmitt trigger with a precise hysteresis band of $\frac{5}{8}$V, bounds the integrator. The output of IC_2 will be a square wave with almost rail-to-rail swing. With the components shown, the circuit exhibits the following frequency of operation:

$$f_{OUT} = V_{IN} \times 10\ \text{Hz/V}.$$

Changing C_1 can alter the equation. The circuit operates well up to a few hundred hertz. **EDN**

Authors' biographies

Derek F Bowers is a senior fellow at Precision Monolithics Inc (PMI) (Santa Clara, CA) where he works on the definition and design of precision linear ICs. Derek has been with PMI for eight years. He obtained a BSc in physics and math from the University of Sheffield in the UK and has four patents. In his spare time he collects and plays unusual musical instruments.

Art Kapoor is a product marketing engineer for PMI. He has a BS in electrical engineering and computer science from the University of California at Berkeley and an MBA from the University of Michigan. Art likes to go skiing and backpacking on weekends.

Andy Jenkins is the manager of analog new-product marketing for PMI. Andy, who has worked for PMI for five years, was previously employed at Burr-Brown and at Analog Devices. He obtained a BSc (Hons) in electronics from Southampton University in the UK. In his spare time, he likes music, rebuilding automobiles, and performing home maintenance.

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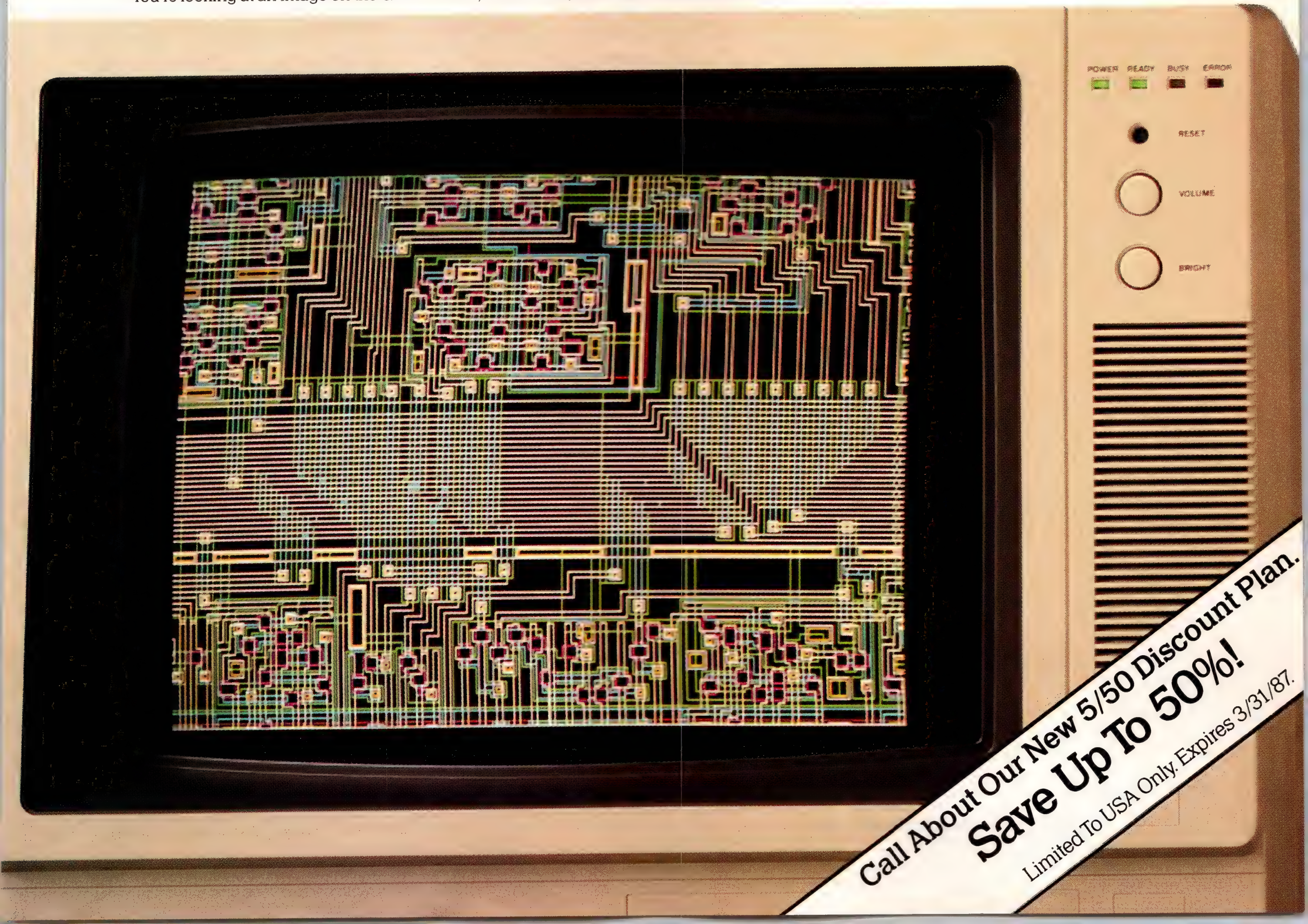

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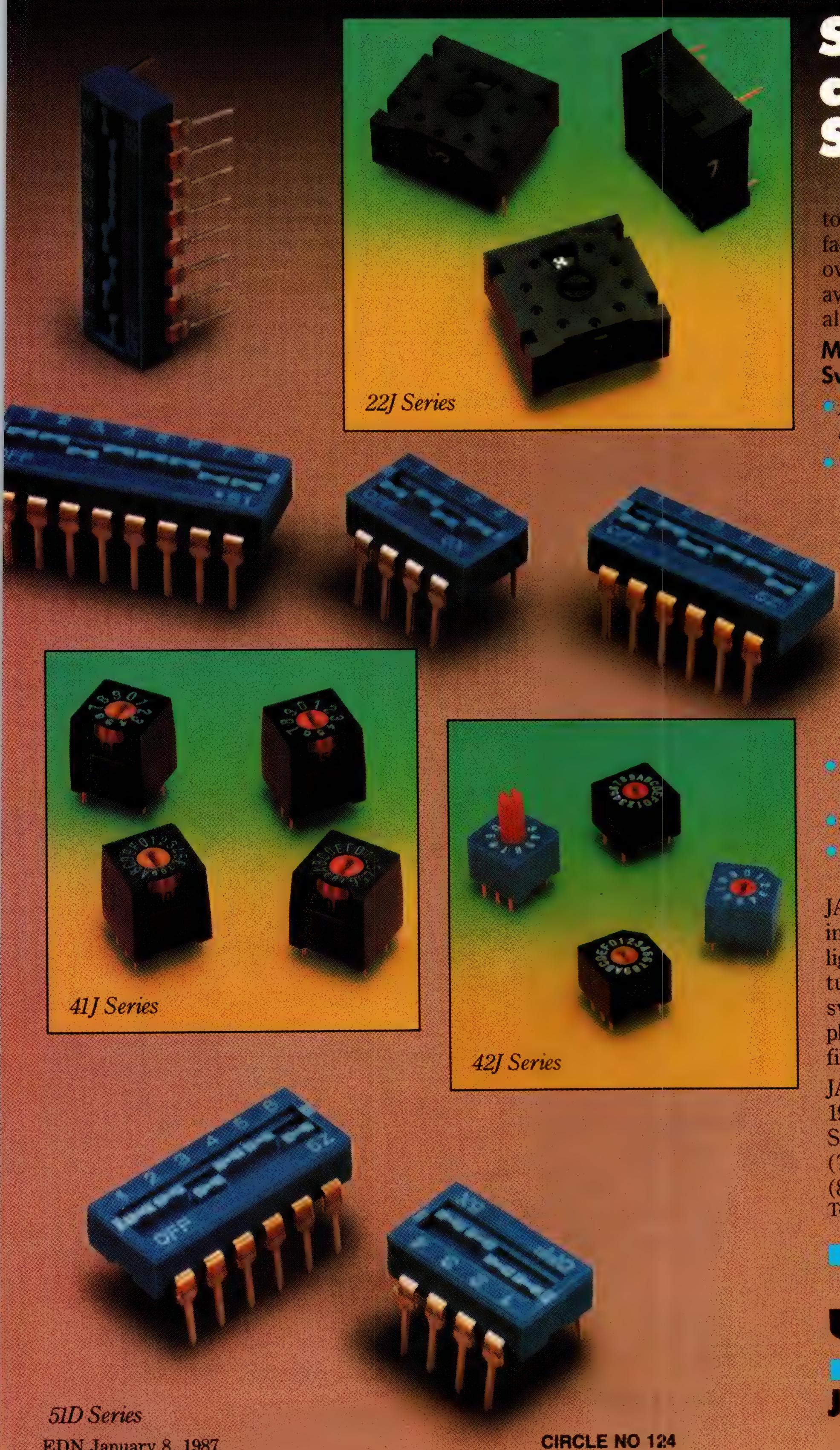

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PRODUCTS

DSP Board Fits IBM PC

The EVK-128 provides signal-processing hardware and FIR-filter design and modification software. You can copy all or part of the system for use in your own signal processor.

GE/Intersil's EVK-128 combines A/D conversion and FIR filtering

JEFF HAIGHT
GE/Intersil Inc.

As digital signal processing becomes simpler, cheaper, and more pervasive, the boundaries between design ideas and design techniques must give way for a more integrated approach to system development. Intersil's EVK-128 board, which occupies one slot in an IBM PC, incorporates analog design and digital signal-processing techniques.

The board works in such applications as PC-based analog or digital data-acquisition and digital filtering systems, finite-impulse-response (FIR) filter design and development systems, or as part of an FIR filter processor for off line or non-real-time data.

The system (**Fig. 1**, below) offers an active antialiasing filter, power-supply circuitry, A/D and D/A converters, and digital interfacing and control circuitry. The board also has FIR filtering circuitry and software for FIR design, modification, plotting, and control. Documentation includes itemized parts lists, schematics, timing

continued on page 19

TECHNOLOGY

Power MOSFET Makers Boost Electrical Specs

Manufacturers improve electrical characteristics and offer a host of package types

TAMMI HARBERT
Staff Editor

Recent power-MOSFET introductions offer lower on-resistance, higher voltage, faster switching, and innovations in onboard intelligence. Packaging improvements include greater electrical isolation and an increased availability of plastic and surface-mount parts.

Among the manufacturers of low-on-resistance devices are some companies well known in the power-MOSFET industry: Siliconix, Fairchild, International rectifier, and General Instrument. Newer manufacturers—IXYS, for example, have also entered the arena.

Low-on-resistance parts
Made for applications requiring low on-resistance, Siliconix's SMM70N05 is built using the company's MOSPower-6 technology, which produces a chip density of 1.6M transistors/in². The device has an 18-mΩ on-resistance with a continuous current rating of 70A. The 50V SMM70N05, a follow-on to the company's SMP60N05 and SMM60N05, is available in TO-3 packaging for $10.11 (1000).

Like the SMM70N05, the SMP- and SMM60N05 are 50V MOSPower-6 devices. Unlike the newer device, however, these parts offer current and on-resistance of 60A and 23 mΩ respectively. Another de-

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CAREERS

The Temptations of Temping

Once confined to the clerical realm, temping grows in popularity among EEs.

RUTH CLOGSTON

Chris Clark, a 30-year-old programming consultant from Hopkinton, MA, has worked as a contractor for six months. He started temping because he wanted freedom and independence—he is developing his own software and needs to avoid the conflicts of interest

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COMPANIES WITH EXPANDED OPTIONS

EEs are increasingly being drawn toward temping

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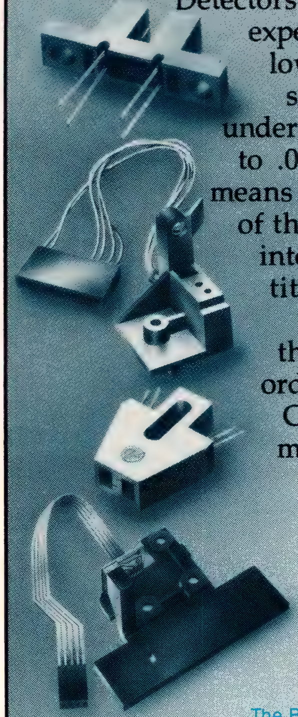

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CIRCLE NO 126

EDN

1987

Calendar of Electronics Industry Events

Your Own Personal Copy

Here's your personal copy of EDN's 1987 Calendar of Electronic Industry Events...a full twelve month comprehensive guide, crammed full of dates and locations for national and international conventions, conferences, seminars, meetings, exhibits and more.

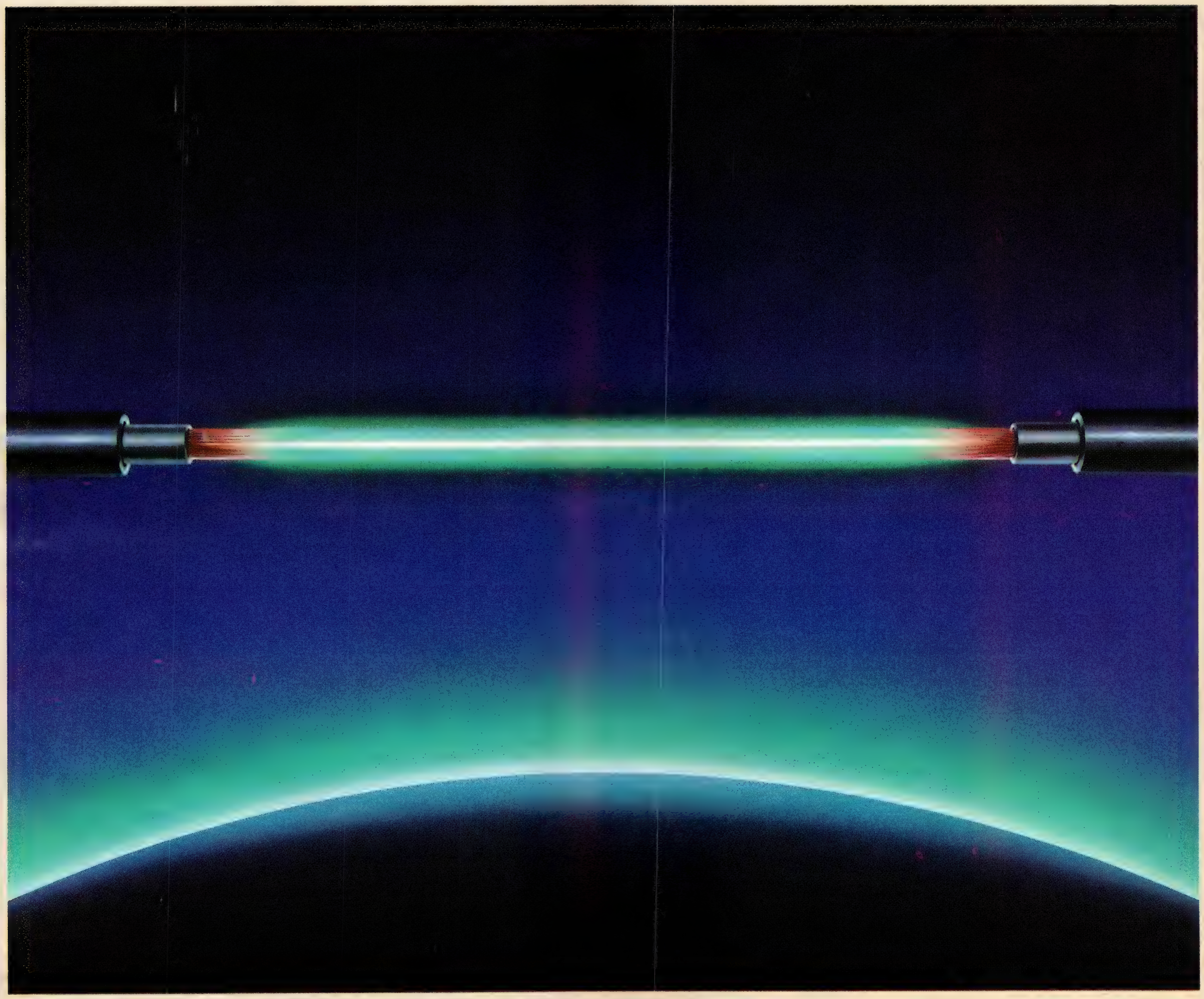
It's removable too! Just tear it out and keep it with you. You'll find this calendar a most valuable planning aid and reference source, all year long. We've included an inquiry reply card for your convenience in requesting information from the companies featured in the calendar.

Easy To Remove, Valuable All Year!

EDN

A Guide to Electronics and Computer Industry Events

1987 Calendar



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TOSHIBA

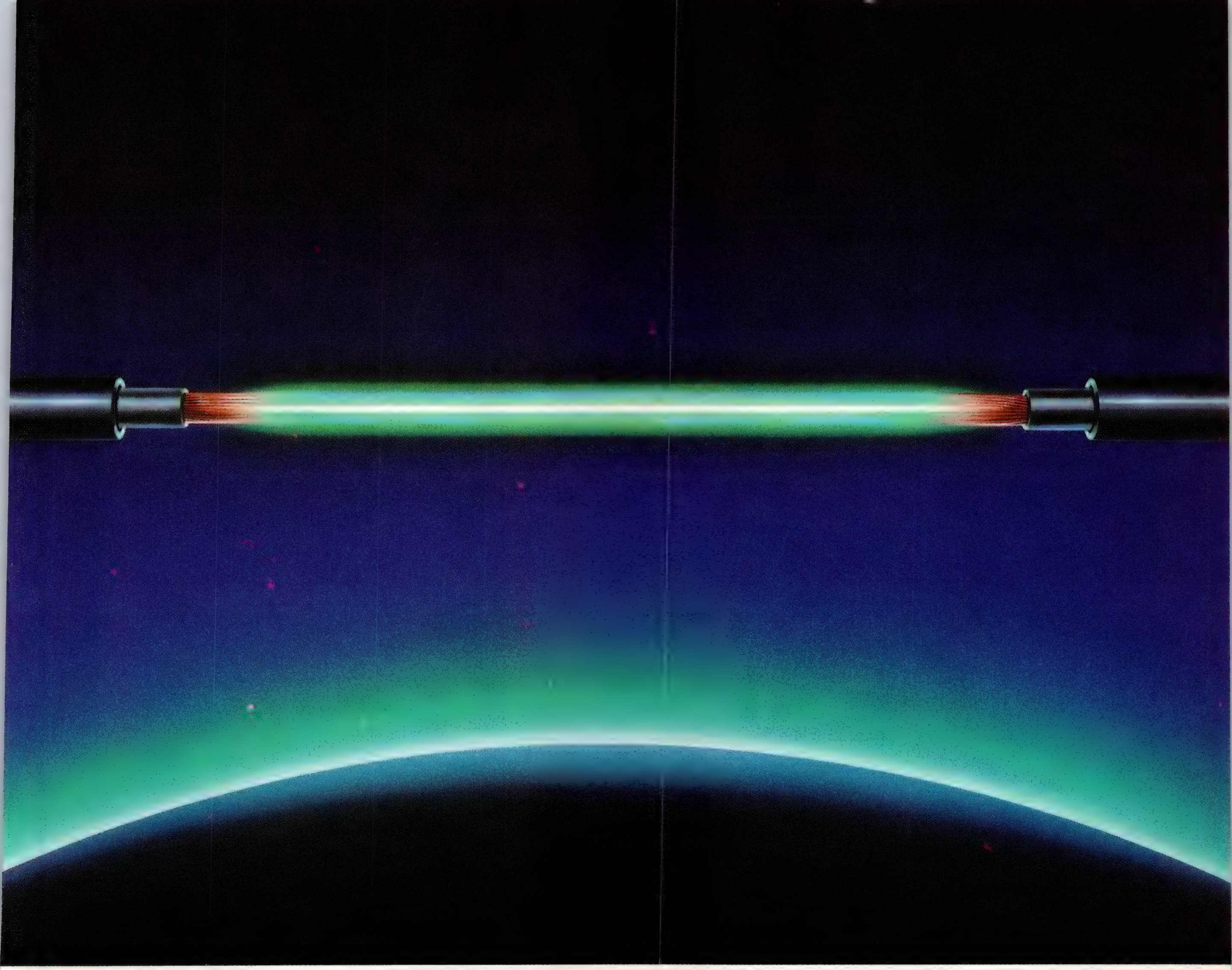
EDN

CALENDAR OF
ELECTRONICS AND
COMPUTER INDUSTRY
EVENTS

January 1987

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
				1 NEW YEAR'S DAY	**2**	**3**
4	**5**	**6**	**7**	**8**	**9**	**10**
11	**12**	**13**	**14**	**15**	**16**	**17**
18	**19**	**20**	**21**	**22**	**23**	**24**
25	**26**	**27**	**28**	**29**	**30**	**31**

- **6-8 ATE West**
  Anaheim Convention Center, Anaheim, CA (Steve Schuldenfrei, MG Expositions Group, 1050 Commonwealth Ave., Boston, MA 02215, 617/232-3976)
- **6-9 20th Hawaii International Conference on System Sciences**
  Kona Surf Hotel, Kailua-Kona, HI (Ralph H. Sprague, University of Hawaii, R-303, College of Business Administration, Honolulu, HI 96822, 808/948-7430)
- **8 Invitational Computer Conference-OEM Series**
  Irvine Hilton & Towers, Irvine, CA (Susie Ring, B.J. Johnson & Associates, Inc., 3151 Airway Ave., #C-2, Costa Mesa, CA 92626, 714/957-0171)
- **8-9 American Society of Test Engineers Annual Conference**
  Anaheim, CA (ASTE, 114 N. Hale St., Suite 2B, Wheaton, IL 60187, 312/260-1055)
- **12 Semiconductor Packaging**
  Scottsdale, AZ (Pat Fruscello, Integrated Circuit Engineering Corp., 15022 N. 75th St., Scottsdale, AZ 85260-2476, 602/998-9780)
- **12-15 SMART III (Surface Mounting and Reflow Technology) Conference**
  New Orleans Hyatt Regency, New Orleans, LA (Anthony Hilvers, The Institute for Interconnecting and Packaging Electronic Circuits, 7380 Lincoln Ave., Lincolnwood, IL 60646, 312/677-2850)
- **12-15 MECOM 87**
  Exhibition Centre Bahrain (Gerald G. Kallman, Kallman Associates, Five Maple Court, Ridgewood, NJ 07450, 201/652-7070)
- **13 Invitational Computer Conference-PC Reseller Series**
  Hotel Int'l London, London, England (Susie Ring, B.J. Johnson & Associates, Inc., 3151 Airway Ave., #C-2, Costa Mesa, CA 92626, 714/957-0171)
- **13-15 PC Fab Expo '87**
  Omni International Hotel and Expo Centre, Orlando, FL (PMS Industries, 1790 Hembree Rd, Alpharetta, GA 30201, 404/475-1818)
- **13-15 Practical IC Fabrication**
  Scottsdale, AZ (Pat Fruscello, Integrated Circuit Engineering Corp., 15022 N. 75th St., Scottsdale, AZ 85260, 602/998-9780)
- **13-15 Failure Avoidance/Analysis**
  Monrovia, CA (Margaret DeRiso, DM Data Inc., 6900 E. Camelback Rd, Suite 1000, Scottsdale, AZ 85251, 602/945-9620)
- **13-15 Annual Battery Conference on Applications and Advances**
  Long Beach, CA (Roseann Schaff-Matheny, Dept. of Electrical Engineering, California State University, 1250 Bellflower Blvd., Long Beach, CA 90840, 213/498-4605)
- **14-16 1987 Multiconference**
  San Diego, CA (The Society for Computer Simulation, P.O. Box 17900, San Diego, CA 92117, 619/277-3888)
- **14-16 Computer Graphics '87**
  The Westgate Hotel, San Diego, CA (Terri McGuire, Frost & Sullivan, Inc., 106 Fulton St., New York, NY 10038-2786, 212/233-1080)
- **15-17 Electronics for National Security Asia Expo (ENSA)**
  World Trade Centre, Singapore (Cahners Exposition Group, P.O. Box 3833, Stamford, CT 06905, 203/964-0000)
- **15-17 International Naval Technology Exposition-Asia (NAVTECH)**
  World Trade Centre, Singapore (Cahners Exposition Group, P.O. Box 3833, Stamford, CT 06905, 203/964-0000)
- **16 Process Control**
  Scottsdale, AZ (Pat Fruscello, Integrated Circuit Engineering Corp., 15022 N. 75th St., Scottsdale, AZ 85260, 602/998-9780)
- **18-21 Symposium on Intelligent Control**
  Hilton Hotel, Philadelphia, PA (Dr. A. Meystel, Drexel University, Dept. of Elec. & Comp. Engr., College of Engineering, Philadelphia, PA 19104, 215/895-2241)
- **20 Basic IC Technology**
  San Jose, CA (Pat Fruscello, Integrated Circuit Engineering Corp., 15022 N. 75th St., Scottsdale, AZ 85260-2476, 602/998-9780)
- **20-21 BUSCON/87-West**
  Los Angeles Airport Hilton Hotel, Los Angeles, CA (Anne Weber, MultiDynamics, Inc., 17100 Norwalk Blvd., Suite 116, Cerritos, CA 90701, 213/402-1610)
- **20-21 SYSCON/87-West**
  Los Angeles Airport Hilton Hotel, Los Angeles, CA (Anne Weber, MultiDynamics, Inc., 17100 Norwalk Blvd., Suite 116, Cerritos, CA 90701, 213/402-1610)
- **20-23 Annual IEEE Design Automation Workshop**
  Gold Canyon Ranch, Appache Junction, AZ (James Armstrong, Electrical Eng. Dept., Virginia Tech, Blacksburg, VA 24061, 703/961-7078)
- **21 Status '87**
  San Jose, CA (Pat Fruscello, Integrated Circuit Engineering Corp., 15022 N. 75th St., Scottsdale, AZ 85260-2476, 602/998-9780)
- **21-23 Usenix Technical Conference**
  Washington, DC (Usenix Association, Box 385, Sunset Beach, CA 90742, 213/592-3243)
- **21-24 Electrotest Japan**
  Harumi Exhibition Centre, Tokyo, Japan (Cahners Exposition Group, P.O. Box 3833, Stamford, CT 06905, 203/964-0000)
- **21-24 Automated Design Engineering for Electronics (ADEE)**
  Harumi Exhibition Centre, Tokyo, Japan (Cahners Exposition Group, P.O. Box 3833, Stamford, CT 06905, 203/964-0000)
- **21-24 Internepcon/Semiconductor International Japan**
  Harumi Exhibition Centre, Tokyo, Japan (Cahners Exposition Group, P.O. Box 3833, Stamford, CT 06905, 203/964-0000)
- **22 Invitational Computer Conference-OEM Series**
  Frankfurt-Sheraton Hotel, Frankfurt, West Germany (Susie Ring, B.J. Johnson & Associates, Inc., 3151 Airway Ave., #C-2, Costa Mesa, CA 92626, 714/957-0171)
- **27 Basic IC Technology**
  Scottsdale, AZ (Pat Fruscello, Integrated Circuit Engineering Corp., 15022 N. 75th St., Scottsdale, AZ 85260-2476, 602/998-9780)
- **27 Invitational Computer Conference-OEM Series**
  Hotel Sofitel Paris, Paris, France (Susie Ring, B.J. Johnson & Associates, Inc., 3151 Airway Ave., #C-2, Costa Mesa, CA 92626, 714/957-0171)
- **27-29 Advanced Semiconductor Equip. Exposition and Technical Conf.**
  Santa Clara, CA (Cartlidge & Associates, 1101 S. Winchester Blvd., M259, San Jose, CA 95128, 408/554-6644)
- **27-29 Reliability and Maintainability Symposium**
  Philadelphia, PA (The American Society of Mechanical Engineers, United Engineering Center, 345 E. 47th St., New York, NY 10017, 212/705-7053)
- **28 Invitational Computer Conference-PC Reseller Series**
  Hotel Sofitel Paris, Paris, France (Susie Ring, B.J. Johnson & Associates, Inc., 3151 Airway Ave., #C-2, Costa Mesa, CA 92626, 714/957-0171)
- **28-29 12th Annual San Diego Electronics Show**
  Del Mar Fairgrounds, Del Mar, CA (Harry Schwartz, Epic Enterprises, Inc., 6151 Fairmount Ave., Suite 115, San Diego, CA 92120, 619/284-9268)
- **28-30 Computer Graphics New York '87**
  New York, NY (Exhibition Marketing and Management, 8300 Greensboro Dr., Suite 690, McLean, VA 22102, 703/893-4545)
- **28-31 India Comm**
  Taj Palace Hotel, New Delhi, India (Cahners Exposition Group, P.O. Box 3833, Stamford, CT 06905, 203/964-0000)
- **29 Invitational Computer Conference-OEM Series**
  Bonaventure Hotel/Spa, Ft. Lauderdale, FL (Susie Ring, B.J. Johnson & Associates, Inc., 3151 Airway Ave., #C-2, Costa Mesa, CA 92626, 714/957-0171)
- **31 The Chinese Institute of Engineers Annual Winter Conference**
  Santa Clara, CA (Regina Lau, The Chinese Institute of Engineers, P.O. Box 391, Los Altos, CA 94022, 415/325-5499)



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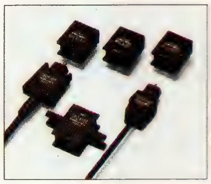
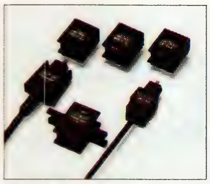
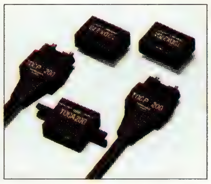
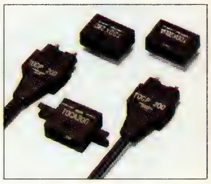

TOSLINK™ GH
TOML170/170A


TOSLINK™ HH
TOML180/180A


TOSLINK™ GH
TOML270/270A


TOSLINK™ HH
TOML280/280A

TOSLINK™ GH/HH SERIES

Name	Direction	Data rate	Transmission distance (m)	Pulse width distortion	I/O	Power supply	Operating temperature*
TOML170/270	Simplex/ Duplex	DC to 3Mb/s (NRZ)	APF 5 PCF 1300	less than ±110 ns	TTL	+5V	−40 to 70°C
TOML170A/270A			APF 50 PCF 100				
TOML180/280			APF 5 PCF 1300				−40 to 85°C
TOML180A/280A			APF 50 PCF 100				

GH: General Use HH: High Reliability Use *Module

TOSHIBA

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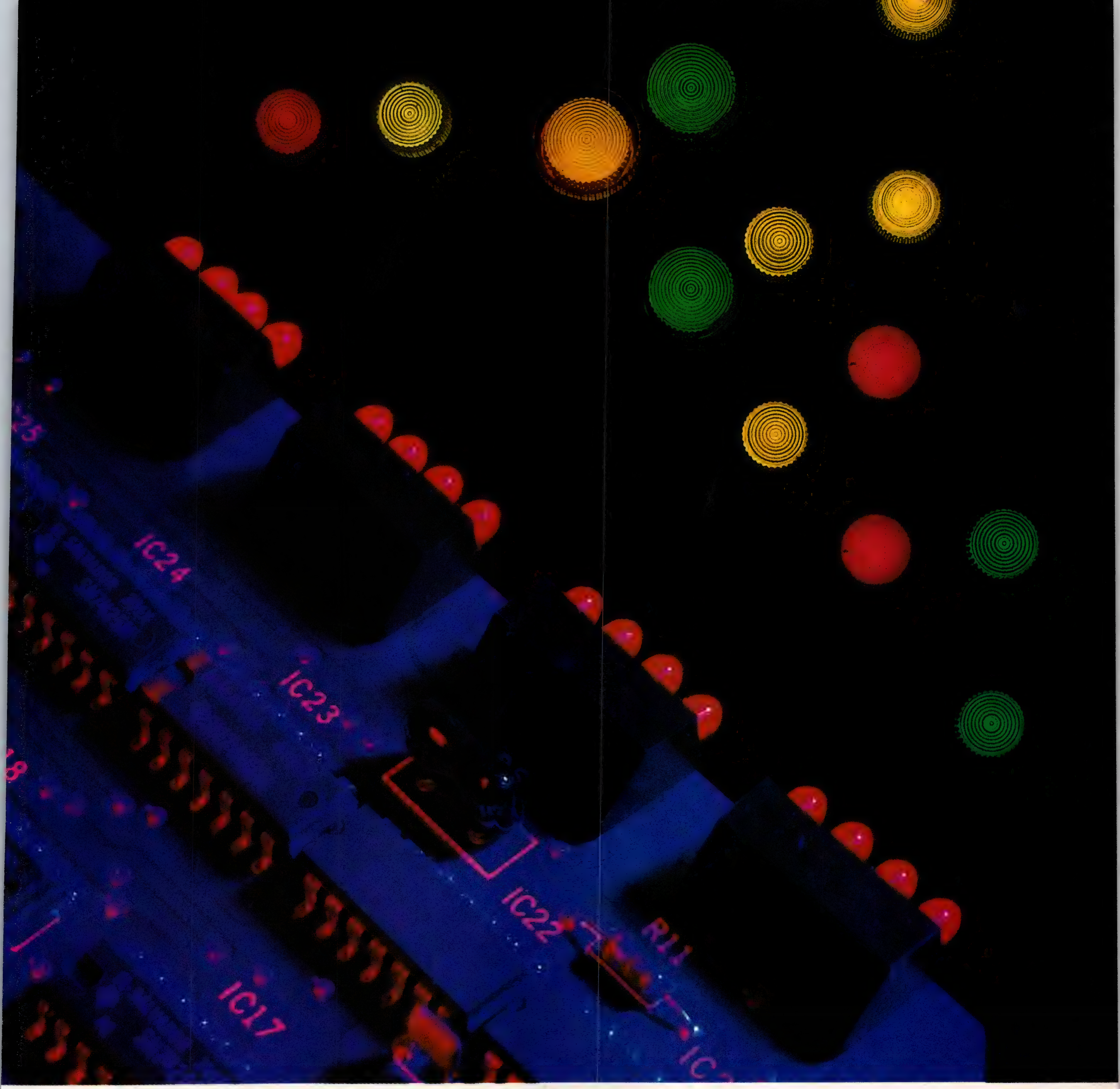
EDN

CALENDAR OF
ELECTRONICS AND
COMPUTER INDUSTRY
EVENTS

February 1987

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
1	2	3	4	5	6	7
8	9	10	11	12 LINCOLN'S BIRTHDAY	13	14 VAL. DAY
15	16 WASHINGTON'S BIRTHDAY	17	18	19	20	21
22	23	24	25	26	27	28

- **1-6 IEEE Power Engineering Society Winter Meeting**
  Marriott & Monteleone Hotels, New Orleans, LA (H.E. Markel, Louisiana Power & Light Co., 142 Delarond St., New Orleans, LA 70114, 504/363-8841)
- **2-5 Seventh Annual Florida Instructional Computing Conference**
  Sheraton Twin Towers Convention Center and Howard Johnson's Florida Center Hotel, Orlando, FL (David Brittain, Florida Department of Education, Educational Technology Section, Knott Building, Tallahassee, FL 32399, 904/488-0980)
- **2-6 3rd International Conference on Data Engineering**
  Pacifica Hotel, Los Angeles, CA (Gio Wiederhold, Dept. of Computer Science, Stanford University, Stanford, CA 94305, 415/497-0685)
- **3 Basic IC Technology**
  Orlando, FL (Pat Fruscello, Integrated Circuit Engineering Corp., 15022 N. 75th St., Scottsdale, AZ 85260, 602/998-9780)
- **3 BUSTOPS**
  Hotel Europa, Raleigh, NC (Anne Weber, MultiDynamics, Inc., 17100 Norwalk Blvd., Suite 116, Cerritos, CA 90701, 213/402-1610)
- **3 Invitational Computer Conference-OEM Series**
  Hotel Executive, Milano, Italy (Susie Ring, B.J. Johnson & Associates, Inc., 3151 Airway Ave., #C-2, Costa Mesa, CA 92626, 714/957-0171)
- **3-5 8th AFCEA Western Conference & Exposition**
  Disneyland Hotel, Anaheim, CA (The Armed Forces Communications and Electronics Association, 4400 Fair Lakes Court, Fairfax, VA 22033, 703/631-6125)
- **4 Status '87**
  Orlando, FL (Pat Fruscello, Integrated Circuit Engineering Corp., 15022 N. 75th St., Scottsdale, AZ 85260, 602/998-9780)
- **4-5 Failure Analysis Avoidance**
  Scottsdale, AZ (Pat Fruscello, Integrated Circuit Engineering Corp., 15022 N. 75th St., Scottsdale, AZ 85260, 602/998-9780)
- **5 BUSTOPS**
  Radisson Orlando, Orlando, FL (Anne Weber, MultiDynamics, Inc., 17100 Norwalk Blvd., Suite 116, Cerritos, CA 90701, 213/402-1610)
- **9-11 Modern Electronic Packaging**
  Orlando, FL (Technology Seminars, Box 487, Lutherville, MD 21093, 301/269-4102)
- **10 Basic IC Technology**
  Newport Beach, CA (Pat Fruscello, Integrated Circuit Engineering Corp., 15022 N. 75th St., Scottsdale, AZ 85260-2476, 602/998-9780)
- **10 Invitational Computer Conference-Computer Graphic Series**
  Red Lion Inn, San Jose, CA (Susie Ring, B.J. Johnson & Associates, Inc., 3151 Airway Ave., #C-2, Costa Mesa, CA 92626, 714/957-0171)
- **10-12 Systems Design and Integration Conference**
  Santa Clara Convention Center, Santa Clara, CA (Alexes Razevich, Electronic Conventions Management, 8110 Airport Boulevard, Los Angeles, CA 90045, 213/772-2965)
- **10-12 Communication Networks Conference & Exposition**
  Convention Center, Washington, DC (CW/Conference Management Group, 375 Cochituate Rd., Box 9171, Framingham, MA 01701, 617/879-0700)
- **11 Status '87**
  Newport Beach, CA (Pat Fruscello, Integrated Circuit Engineering Corp., 15022 N. 75th St., Scottsdale, AZ 85260, 602/998-9780)
- **11-13 Executive Conference**
  Naples, FL (Mary Harrington, Association for Information and Image Management, 1100 Wayne Ave., Suite 1100, Silver Spring, MD 20910, 301/587-8202)
- **15-19 Energy Sources Technology Conference and Exhibition**
  Dallas, TX (The American Society of Mechanical Engineers, United Engineering Center, 345 E. 47th St., New York, NY 10017, 212/705-7053)
- **16-19 Electronic Imaging West**
  Anaheim Marriott, Anaheim, CA (Steve Schuldenfrei, MG Expositions Group, 1050 Commonwealth Ave., Boston, MA 02215, 617/232-3976)
- **17-18 Information Services Seminar**
  Tokyo, Japan (Semiconductor Equipment and Materials Institute, Inc., 805 East Middlefield Rd., Mountain View, CA 94043, 415/964-5111)
- **17-19 Eastern Telecommunications Showcase**
  Indianapolis, IN (Henry Wieland, Jr., U.S. Telephone Assoc. and US. Telecommunications Suppliers Assoc., 900 19th St., NW, Suite 800, Washington, DC 20006, 202/835-3162)
- **17-20 The Which Computer? Show**
  National Exhibition Centre, Birmingham, England (Cahners Exposition Group, P.O. Box 3833, Stamford, CT 06905, 203/964-0000)
- **18 Basic IC Technology**
  Boston, MA (Pat Fruscello, Integrated Circuit Engineering Corp., 15022 N. 75th St., Scottsdale, AZ 85260, 602/998-9780)
- **19 Status '87**
  Boston, MA (Pat Fruscello, Integrated Circuit Engineering Corp., 15022 N. 75th St., Scottsdale, AZ 85260, 602/998-9780)
- **19 Invitational Computer Conference-OEM Series**
  Europa Hotel, Raleigh, NC (Susie Ring, B.J. Johnson & Associates, Inc., 3151 Airway Ave., #C-2, Costa Mesa, CA 92626, 714/957-0171)
- **22-28 3rd Artificial Intelligence Applications**
  Hyatt Orlando, Kissimee, FL (AI Conference, Jan Aikins, Aion Corp., 101 University Ave., 4th Fl., Palo Alto, CA 94301, 415/328-9595)
- **23-26 IEEE Computer Society COMPCON Spring '87**
  Cathedral Hill Hotel, San Francisco, CA (Glen G. Langdon, Conference Chairman, IBM, Dept. K54-802, 650 Harry Rd., San Jose, CA 95120, 408/927-1818)
- **24 Status '87**
  Zurich, Switzerland (Pat Fruscello, Integrated Circuit Engineering Corp., 15022 N. 75th St., Scottsdale, AZ 85260, 602/998-9780)
- **24 Invitational Computer Conference-Computer Graphic Series**
  The Registry, Dallas, TX (Susie Ring, B.J. Johnson & Associates, Inc., 3151 Airway Ave., #C-2, Costa Mesa, CA 92626, 714/957-0171)
- **24-26 Nepcon West '87**
  Anaheim Convention Center, Anaheim, CA (Jerry Carter, Cahners Exposition Group, 1350 E. Touhy Ave., Des Plaines, IL 60018, 312/299-9311)
- **25-27 West Lightwave Expo**
  San Jose, CA (Lightwave, 235 Bear Hill Rd., Waltham, MA 02154, 617/890-2700)
- **25-27 Phoenix Conference on Computer and Communications**
  Scottsdale, AZ (Dr. Forouzan Golshani, Dept. of Computer Science, Arizona State University, Tempe, AZ 85287, 602/965-2855)
- **25-27 1987 IEEE International Solid-State Circuits Conference**
  New York, NY (Lewis Winner, 301 Almeria Ave., Coral Gables, FL 33134, 305/446-8193)
- **26 Optical Discs: An Information Revolution**
  IEEE Videoconferences, Seminars via Satellite (IEEE Continuing Education Dept., 445 Hoes Lane, Piscataway, NJ 08854, 201/981-0060)



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CIRCLE NO 53

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When you think fast, think Toshiba. We have the organizations and the speeds to meet your requirements.

In the popular 4K x4, we offer a 35ns version in the standard 20 pin type and in a 22 pin configuration with output enable function. The output enable helps eliminate bus contention, increasing speed. In addition, we will soon introduce a 25ns version in both configurations.

We were first with 2K x 8 devices which are ideally suited for cache memory applications. Now — to complement our 35ns versions — we are developing a 25ns device.

For high speed bit-wide applications, we are in full production of two versions of our CMOS 64K x 1 SRAMs. One with access times to 45ns, and one with the lowest stand-by power in the industry at only 100μA.

Another new product family being introduced is the 16K x 4 CMOS static RAM. Both the standard 22 pin device and the 24 pin device with the additional output enable function have speeds to 35ns. A 25ns version is in development.

For additional byte-wide applications, we are introducing an 8K x 8 device with access times to 35ns. Packaging is standard 28 pin 600 mil plastic dip. For applications where parity is required, we have an 8K x 9 with speeds to 35ns in a 28 pin 300 mil ceramic dip.

So when you're thinking fast, think Toshiba, the power — and the speed — in static RAMs. Toshiba. The Power in High Speed RAMs.

FAMILY TYPE: HIGH SPEED MOS STATIC RAMS

PART	ORG'N	SPEED	PACKAGE		SAMPLES	PROD'N
TMM2068D	4KX4	55	20P	CDIP	NOW	NOW
TMM2068D	4KX4	45	20P	CDIP	NOW	NOW
TMM2068D	4KX4	35	20P	CDIP	NOW	NOW
TMM2068AD	4KX4	25	20P	CDIP	9/86	11/86
TMM2078D	4KX4	55	22P	CDIP	NOW	NOW
TMM2078D	4KX4	45	22P	CDIP	NOW	NOW
TMM2078D	4KX4	35	22P	CDIP	NOW	NOW
TMM2078AD	4KX4	25	22P	CDIP	9/86	11/86
TMM2018D	2KX8	55	24P	CDIP	NOW	NOW
TMM2018D	2KX8	45	24P	CDIP	NOW	NOW
TMM2018D	2KX8	35	24P	CDIP	NOW	NOW
TMM2018AD	2KX8	25	24P	CDIP	12/86	12/86
TMM2089C	8KX9	45	28P	SBDIP	NOW	10/86
TMM2089C	8KX9	35	28P	SBDIP	NOW	10/86
TMM2088P	8KX8	45	28P	DIP	9/86	12/86
TMM2088P	8KX8	35	28P	DIP	9/86	12/86
TC55416P	16KX4	45	22P	DIP	11/86	2/87
TC55416P	16KX4	35	22P	DIP	11/86	2/87
TC55416P	16KX4	25	22P	DIP	UNDER DEVELOPMENT	
TC55417P	16KX4	45	24P	DIP	11/86	2/87
TC55417P	16KX4	35	24P	DIP	11/86	2/87
TC55417P	16KX4	25	24P	DIP	UNDER DEVELOPMENT	
TC5561P	64KX1	70	22P	DIP	NOW	NOW
TC5561P	64KX1	55	22P	DIP	NOW	NOW
TC5562P	64KX1	55	22P	DIP	NOW	NOW
TC5562P	64KX1	45	22P	DIP	NOW	NOW

NOTE: DIP = PLASTIC CDIP = CERDIP SBDIP = SIDE BRAZED CERAMIC

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CIRCLE NO 57

EDN

CALENDAR OF
ELECTRONICS AND
COMPUTER INDUSTRY
EVENTS

March 1987

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
1	**2**	**3**	**4**	**5**	**6**	**7**
8	**9**	**10**	**11**	**12**	**13**	**14**
15	**16**	**17** ST. PATRICK'S DAY	**18**	**19**	**20**	**21**
22	**23**	**24**	**25**	**26**	**27**	**28**
29	**30**	**31**				

• 1-5 Sixth Intl. Symposium on Offshore Mechanics and Arctic Engineering
Houston, TX (The American Society of Mechanical Engineers, United Engineering Center, 345 E. 47th St., New York, NY 10017, 212/705-7053)

• 2-5 Spring National Design Engineering Show & Conference
McCormick Place, Chicago, IL (Cahners Exposition Group, P.O. Box 3833, Stamford, CT 06905, 203/964-0000)

• 2-6 IEEE Applied Power Electronics Conference and Expo
San Diego, CA (Melissa Widerkehr, APEC '87, 655 15th St. NW, Suite 300, Washington, DC 20005, 202/347-5900)

• 3 Invitational Computer Conference-OEM Series
La Mansion Hotel, Austin, TX (Susie Ring, B.J. Johnson & Associates, Inc., 3151 Airway Ave., #C-2, Costa Mesa, CA 92626, 714/957-0171)

• 3-5 COMDEX in Japan
Harumi Exhibition Center, Tokyo, Japan (Linda M. Hanson, The Interface Group, Inc., 300 First Ave., Needham, MA 02194, 617/449-6600)

• 3-5 CEPS: Corporate Electronic Publishing Systems Showcase/Conference
McCormick Place, Chicago, IL (Cahners Exposition Group, P.O. Box 3833, Stamford, CT 06905, 203/964-0000)

• 4-6 AEA Spring Financial Conference
Monterey, CA (Pamela A. Turner, American Electronics Association, 2670 Hanover St., P.O. Box 10045, Palo Alto, CA 94303, 415/857-9300)

• 9-10 Automated Manufacturing: Computers, Communications and Controls
The Don Cesar Beach Resort, St. Petersburg, FL (Frost & Sullivan Inc., 212/233-1080)

• 9-11 OAC 87
Dallas, TX (AFIPS, 1899 Preston White Dr., Reston, VA 22091, 703/620-8900)

• 10-12 SEMICON/Europa '87
Zurich, Switzerland (Semiconductor Equipment and Materials Institute, Inc., 805 East Middlefield Rd., Mountain View, CA 94043, 415/964-5111)

• 10-12 FOSE '87; FOSE Software '87; FOSE Computer Graphics '87
Washington Convention Center, Washington, DC (Teresa Robinson, National Trade Productions, Inc., 2111 Eisenhower Ave., Suite 400, Alexandria, VA 22314, 703/683-8500)

• 10-12 Failure Avoidance/Analysis
Orlando, FL (Margaret DeRiso, DM Data Inc., 6900 E. Camelback Rd, Suite 1000, Scottsdale, AZ 85251, 602/945-9620)

• 11-13 20th Annual Simulation Symposium
Bay Harbor Inn, Tampa, FL (James Gantt, US Aray-AIRMICS, 115 O'Keefe Bldg, GIT, Atlanta, GA 30332, 404/894-3107)

• 12-13 Northeast Bioengineering Conference
Philadelphia, PA (IEEE, 6411, Chillum P1 NW, Washington, DC 20012)

• 13 The Cost Edge
Orlando, FL (Margaret DeRiso, DM Data Inc., 6900 E. Camelback Rd, Suite 1000, Scottsdale, AZ 85251, 602/945-9620)

• 13-15 Technology Executives Conference
San Francisco, CA (The American Society of Mechanical Engineers, United Engineering Center, 345 E. 47th St., New York, NY 10017, 212/705-7053)

• 16 State of the Industry Forum
Dallas, TX (Infomart, 1950 Stemmons Freeway, Dallas, TX 75207, 800/367-7100)

• 16-18 Modern Electronic Packaging
Torrance, CA (Technology Seminars, Box 487, Lutherville, MD 21093, 301/269-4102)

• 16-19 International Military Fiber Optic and Communications Exposition
Washington, DC (Information Gatekeepers, 214 Harvard Ave., Boston, Ma 02134, 617/232-3111)

• 17 BUSTOPS
Adams Mark Hotel, Philadelphia, PA (Anne Weber, MultiDynamics, Inc., 17100 Norwalk Blvd., Suite 116, Cerritos, CA 90701-2750, 213/402-1610)

• 17 Invitational Computer Conference-OEM Series
Red Lion Inn, San Jose, CA (Susie Ring, B.J. Johnson & Associates, Inc., 3151 Airway Ave., #C-2, Costa Mesa, CA 92626, 714/957-0171)

• 17-19 VAR Congress '87
Dallas, TX (Infomart, 1950 Stemmons Freeway, Dallas, TX 75207, 800/367-7100)

• 17-19 6th Symposium of Reliability in Distributed Software and Database Systems
Williamsburg Hilton, Williamsburg, VA (Edwin C. Foudriat, NASA, Langley Research Center, Info Syst. Div., Hampton, VA 23665, 804/865-3535)

• 17-20 ELKON
Helsinki Fair Centre, Helsinki, Finland (Gerald G. Kallman, Kallman Associates, Five Maple Court, Ridgewood, NJ 07450, 201/652-7070)

• 19 BUSTOPS
Sheraton National, Arlington, VA (Anne Weber, MultiDynamics, Inc., 17100 Norwalk Blvd., Suite 116, Cerritos, CA 90701, 213/402-1610)

• 19-20 Seminar on Strategies for Successful Marketing in the Technology Industries
Torrance Marriott Hotel, Torrance, CA (Technology Seminars, 301/269-4102)

• 23-26 WESTEC '87
Los Angeles Convention Center, Los Angeles, CA (Mark Kholos, Society of Manufacturing Engineers, One SME Drive, P.O. Box 930, Dearborn, MI 48121, 313/271-1500)

• 24-26 Southcon/87
Georgia World Congress Center, Atlanta, GA (Alexes Razevich, Electronic Conventions Management, 8110 Airport Boulevard, Los Angeles, CA 90045, 213/772-2965)

• 22-26 Solar Energy Conference
Honolulu, HI (The American Society of Mechanical Engineers, United Engineering Center, 345 E. 47th St., New York, NY 10017, 212/705-7053)

• 22-26 Thermal Engineering Conference ASME/JSME
Honolulu, HI (The American Society of Mechanical Engineers, United Engineering Center, 345 E. 47th St., New York, NY 10017, 212/705-7053)

• 23-26 NCGA Computer Graphics '87
Philadelphia Civic Center, Philadelphia, PA (Nancy A. Flower, National Computer Graphics Association, 2722 Merrilee Drive, Suite 200, Fairfax, VA 22031, 703/698-9600)

• 24-26 The Internepcon Production Show & Conference
National Exhibition Centre, Birmingham, England (Cahners Exposition Group, P.O. Box 3833, Stamford, CT 06905, 203/964-0000)

• 26-28 Internepcon/Semiconductor International Korea
Korean Exhibition Centre, Seoul, Korea (Cahners Exposition Group, P.O. Box 3833, Stamford, CT 06905, 203/964-0000)

• 29-April 2 IPC Spring Semi-Annual Meeting
Westin Peachtree Plaza, Atlanta, GA (Anthony Hilvers, The Institute for Interconnecting and Packaging Electronic Circuits, 7380 Lincoln Ave., Lincolnwood, IL 60646, 312/677-2850)

• 30-April 2 Interface '87
Las Vegas Convention Center, Las Vegas, NV (Linda M. Hanson, The Interface Group, Inc., 300 First Ave., Needham, MA 02194, 617/449-6600)

• 30-April 2 9th IEEE International Conference on Software Engineering
Monterey, CA (William Riddle, Software Design & Analysis, Inc., 1760 Bear Mountain Dr., Boulder, CO 80303, 303/499-4782)

• 30-April 3 IEEE INFOCOM '87
Hotel Meridien, San Francisco, CA (IEEE Infocom '87, 1730 Massachusetts Ave., N.W., Washington, DC 20036, 202/371-0101)

• 31-April 2 ADEE: Automated Design Engineering for Electronics/West
Anaheim Convention Center, Anaheim, CA (Cahners Exposition Group, P.O. Box 3833, Stamford, CT 06905, 203/964-0000)

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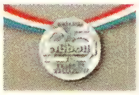

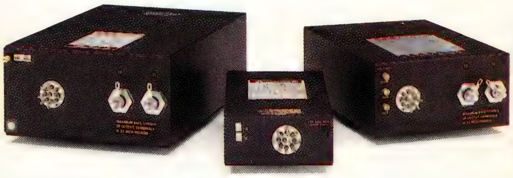

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CIRCLE NO 58

EDN

CALENDAR OF
ELECTRONICS AND
COMPUTER INDUSTRY
EVENTS

April 1987

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19 EASTER	20	21	22	23	24	25
26	27	28	29	30		

- **1-8 Microtronics '87**
  Hannover, West Germany (Hannover Fairs USA, Box 7066, Princeton, NJ 08540, 609/987-1202)
- **2 Invitational Computer Conference-OEM Series**
  Sheraton Tara Hotel, Nashua, NH (Susie Ring, B.J. Johnson & Associates, Inc., 3151 Airway Ave., #C-2, Costa Mesa, CA 92626, 714/957-0171)
- **3-4 4th International Workshop Software Specification and Design**
  Sheraton Inn, Monterey, CA (David Marca, Digital Equipment Corp. Intelligent System Tech Group, 77 Reed Rd., MS HLO2-3/CID, Hudson, MA 01749)
- **5-8 SOUTHEASTCON '87**
  Holiday Inn Tampa Int'l Airport, Tampa, FL (David C. McLaren, 813/224-4409)
- **5-9 Conference on Human Factors in Computing Systems and Graphics Interface**
  Toronto, Canada (Wendy Walker, Computer Systems Research Office, University of Toronto, 10 Kings College Rd., Rm. 2002, Toronto, Ontario, Canada M5S 1A4, 416/978-5184)
- **5-10 AEA/UCLA Senior Executive Program**
  UCLA, Los Angeles, CA (Mary Horngren Frost, American Electronics Association, 2670 Hanover St., P.O. Box 10045, Palo Alto, CA 94303, 415/857-9300)
- **6-9 Eastern Simulation Conferences**
  Orlando, FL (The Society for Computer Simulation, P.O. Box 17900, San Diego, CA 92117, 619/277-3888)
- **7-9 International Reliability Physics Symposium**
  Town & Country Hotel, San Diego, CA (Anant G. Sabnis, AT&T Bell Laboratories, 1247 S. Cedar Crest Blvd., Allentown, PA 18103, 215/770-3598)
- **7-9 Nepcon Southeast '87**
  Orange County Convention Center, Orlando, FL (Janet Schafer, Cahners Exposition Group, 1350 E. Touhy Ave., Des Plaines, IL 60018, 312/299-9311)
- **7-9 Electro/87**
  Jacob Javits Convention Center, New York, NY (Alexes Razevich, Electronic Conventions Management, 8110 Airport Boulevard, Los Angeles, CA 90045, 213/772-2965)
- **7-9 Mini/Micro Northeast-87**
  Jacob Javits Convention Center, New York, NY (Alexes Razevich, Electronic Conventions Management, 8110 Airport Boulevard, Los Angeles, CA 90045, 213/772-2965)
- **7-9 Electrotest**
  Orange County Convention Center, Orlando, FL (Cahners Exposition Group, P.O. Box 3833, Stamford, CT 06905, 203/964-0000)
- **9-10 Satellite Communications Status '87: Technology, Applications & Markets**
  Halloran House, New York, NY (Terri McGuire, Frost & Sullivan, Inc., 106 Fulton St., New York, NY 10038, 212/233-1080)
- **10-12 RAINBOWfest**
  Hyatt Regency Woodfield, Schaumberg, IL (Ira D. Barsky, Falsoft, Inc., The Falsoft Building, `P.O. Box 385, Prospect, KY 40059, 502/228-4492)
- **14-16 Western Telecommunications Showcase**
  Las Vegas, NV (Henry Wieland, Jr., U.S. Telephone Assoc. and US. Telecommunications Suppliers Assoc., 900 19th St., NW, Suite 800, Washington, DC 20006, 202/835-3162)
- **20-25 28th Annual Management Conference**
  Marriott's Desert Springs, Palm Desert, CA (Electronic Representatives Association, 312/649-1333)
- **21 BUSTOPS**
  Sheraton Park Central, Dallas, TX (Anne Weber, MultiDynamics, Inc., 17100 Norwalk Blvd., Suite 116, Cerritos, CA 90701, 213/402-1610)
- **21-22 AFCEA Vital Issues Symposium**
  U.S. Department of State, Washington, DC (The Armed Forces Communications and Electronics Association, 4400 Fair Lakes Court, Fairfax, VA 22033, 703/631-6125)
- **21-23 Modern Electronic Packaging**
  Washington, DC (Technology Seminars, Box 487, Lutherville, MD 21093, 301/269-4102)
- **21-23 Failure Avoidance/Analysis**
  Boston, MA (Margaret DeRiso, DM Data Inc., 6900 E. Camelback Rd, Suite 1000, Scottsdale, AZ 85251, 602/945-9620)
- **21-23 Annual Electrical Overstress Exposition**
  San Jose, CA (EOE, 2504 N Tamiami Trail, Nokomis, FL 33555, 813/966-9521)
- **23 BUSTOPS**
  Hilton Inn, Minneapolis, MN (Anne Weber, MultiDynamics, Inc., 17100 Norwalk Blvd., Suite 116, Cerritos, CA 90701, 213/402-1610)
- **23 Invitational Computer Conference-Computer Graphic Series**
  Sheraton Hotel Towers, Munich, West Germany (Susie Ring, B.J. Johnson & Associates, Inc., 3151 Airway Ave., #C-2, Costa Mesa, CA 92626, 714/957-0171)
- **24 The Cost Edge**
  Boston, MA (Margaret DeRiso, DM Data Inc., 6900 E. Camelback Rd, Suite 1000, Scottsdale, AZ 85251, 602/945-9620)
- **24-30 Semiconductor International China**
  Shanghai Exhibition Centre, Shanghai, China (Cahners Exposition Group, P.O. Box 3833, Stamford, CT 06905, 203/964-0000)
- **26-29 Array Conference**
  Montreal, Canada (Array, Box 23489, Portland, OR 97223, 503/641-3151)
- **27-29 Defect Recognition and Image Processing in III-V Compounds Symposium**
  Monterey, CA (Continuing Education in Engineering, University of California Extension, 2223, Fulton St., Berkeley, CA 94720, 415/642-4151)
- **27-29 IEEE Instrumentation and Measurement Technology Conference**
  Sheraton-Boston Hotel, Boston, MA (Robert Myers, IEEE Instrumentation and Measurement Society, 1700 Westwood Blvd., Los Angeles, CA 90024, 213/475-4571)
- **27-29 Federal DP & Communications Conference & Expo**
  Washington Convention Center, Washington, DC (Linda M. Hanson, The Interface Group, Inc., 300 First Ave., Needham, MA 02194, 617/449-6600)
- **27-29 American Power Conference**
  Palmer House, Chicago, IL (Robert W. Porter, Illinois Institute of Technology, 312/567-3196)
- **27-29 IEEE Computer Society Symposium on Office Automation**
  Gaithersburg, MD (Vincent Lum, Dept. of Computer Science, Naval Postgrad School, Monterey, CA, 408/646-2449)
- **27-30 Annual Conference (Association for Information and Image Management)**
  New York, NY (Mary Harrington, Association for Information and Image Management, 1100 Wayne Ave., Suite 1100, Silver Spring, MD 20910, 301/587-8202)
- **27-30 ROBOTS 11 & 17th International Symposium on Industrial Robots**
  Chicago Hilton & Towers, Chicago, IL (Mark Kholos, Society of Manufacturing Engineers, One SME Drive, P.O. Box 930, Dearborn, MI 48121, 313/271-1500)
- **28-29 The Power Electronics Conference/87-East**
  Boxborough Sheraton, Boxborough, MA (Anne Weber, MultiDynamics, Inc., 17100 Norwalk Blvd., Suite 116, Cerritos, CA 90701, 213/402-1610)
- **28-30 ATE '87**
  Olympia 2, London, England (Network Events Ltd., Printers Mews, Market Hill, Buckingham, MK18 1JX, England, (0280) 815226)
- **29 Invitational Computer Conference-Computer Graphic Series**
  Hotel Intercontinental, London, England (Susie Ring, B.J. Johnson & Associates, Inc., 3151 Airway Ave., #C-2, Costa Mesa, CA 92626, 714/957-0171)

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UNITED
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HAMILTON STANDARD
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CIRCLE NO 54

EDN

CALENDAR OF
ELECTRONICS AND
COMPUTER INDUSTRY
EVENTS

May 1987

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
					1	2
3	4	5	6	7	8	9
10 MOTHER'S DAY	11	12	13	14	15	16
17	18	19	20	21	22	23
24 31	25 MEMORIAL DAY	26	27	28	29	30

• 5 Invitational Computer Conference-PC Reseller Series
Red Lion Inn, San Jose, CA (Susie Ring, B.J. Johnson & Associates, Inc., 3151 Airway Ave., #C-2, Costa Mesa, CA 92626, 714/957-0171)

• 5 Semiconductor Packaging
Bethesda, MD (Pat Fruscello, Integrated Circuit Engineering Corp., 15022 N. 75th St., Scottsdale, AZ 85260, 602/998-9780)

• 5 Invitational Computer Conference-Computer Graphic Series
Hotel Sofitel Paris, Paris, France (Susie Ring, B.J. Johnson & Associates, Inc., 3151 Airway Ave., #C-2, Costa Mesa, CA 92626, 714/957-0171)

• 5-7 Custom Integrated Circuits Conference
Portland, OR (Laura Silzars, 6900 SW Canyon Dr., Portland, OR 97225, 503/292-6347)

• 5-7 Southeast Lightwave Expo
Atlanta, GA (Lightwave, 235 Bear Hill Rd., Waltham, MA 02154, 617/890-2700)

• 5-7 PC Fab Expo '87
Red Lion Inn, San Jose, CA (PMS Industries, 1790 Hembree Road, Alpharetta, GA 30201, 404/475-1818)

• 5-7 Unix Systems '87
Palais des Congres, Paris, France (Network Events Ltd., Printers Mews, Market Hill, Buckingham, MK18 1JX, England, (0280) 815226)

• 6-7 Midwest Electronics Expo
St. Paul Civic Center, St. Paul, MN (Steve Schuldenfrei, MG Expositions Group, 1050 Commonwealth Ave., Boston, MA 02215, 617/232-3976)

• 6-8 AFCEA European Symposium and Exposition
Rome Sheraton Hotel, Rome, Italy (AFCEA Europe, Rue de Geneve 6, Box 2, 1140 Brussels, 2-241-50-12)

• 6-8 Practical IC Fabrication
Bethesda, MD (Pat Fruscello, Integrated Circuit Engineering Corp., 15022 N. 75th St., Scottsdale, AZ 85260, 602/998-9780)

• 6-8 1987 Rome AFCEA European Symposium & Exposition
Rome Sheraton Hotel, Rome, Italy (The Armed Forces Communications and Electronics Association, 4400 Fair Lakes Court, Fairfax, VA 22033, 703/631-6125)

• 10-15 Executive Mfg. Strategy Program
Pajaro Dunes Conference Center, Watsonville, CA (Mary Horngren Frost, American Electronics Association, 2670 Hanover St., P.O. Box 10045, Palo Alto, CA 94303, 415/857-9300)

• 11-15 COMPEURO '87
Congress Center, Hamburg, Germany (Walter E. Proebster, IBM Germany, Dept 3280. Sci., Schoenaichen St. 220, Boeblingen 750, West Germany)

• 12 BUSTOPS
Hilton Inn North, Columbus, OH (Anne Weber, MultiDynamics, Inc., 17100 Norwalk Blvd., Suite 116, Cerritos, CA 90701, 213/402-1610)

• 12-14 Failure Avoidance/Analysis
Monrovia, CA (Margaret DeRiso, DM Data Inc., 6900 E. Camelback Rd, Suite 1000, Scottsdale, AZ 85251, 602/945-9620)

• 13 Computer Integrated Manufacturing
IEEE Videoconferences, Seminars via Satellite (IEEE Continuing Education Dept., 445 Hoes Lane, Piscataway, NJ 08854, 201/981-0060)

• 13-15 Electronic Distribution Show
Bally's, Las Vegas, NV (Joanne Wallace, Electronic Industry Show Corp., 222 South Riverside Plaza, Suite 2710, Chicago, IL 60606, 312/648-1140)

• 13-15 InstrumentAsia 87
Singapore Exhibition Centre, Singapore (Kallman Associates, 201/652-7070)

• 14 BUSTOPS
Skyline Toronto, Toronto, Canada (Anne Weber, MultiDynamics, Inc., 17100 Norwalk Blvd., Suite 116, Cerritos, CA 90701, 213/402-1610)

• 18-19 Seminar on Strategies for Successful Marketing in the Technology Industries
Marriott Philadelphia Airport Hotel, Philadelphia, PA (Technology Seminars, 301/269-4102)

• 18-20 COMDEX International in Europe
Nice Exhibition Center, Nice, France (Linda M. Hanson, The Interface Group, Inc., 300 First Ave., Needham, MA 02194, 617/449-6600)

• 18-21 Computer Arithmetics 8
Como, Italy (Luigi Dadda, Politecnico di Milano, P.zza L. da Vinci 32-20133, Milano, Italy)

• 18-21 8th International Conference on Metallic and Non-Metallic Materials
La Baule, France (Marge Smith, Society for the Advancement of Material & Process Engineering, P.O. Box 2459, Covina, CA 91722, 818/331-0616)

• 18-21 SEMICON/West '87
San Mateo, CA (Semiconductor Equipment and Materials Institute, Inc., 805 East Middlefield Rd., Mountain View, CA 94043, 415/964-5111)

• 19-23 Power Industry Computer Applications Conference (PICA)
Boanventure Hotel, Montreal, Canada (R.D. Masiello, Systems Control, Inc., 1801 Page Mill Rd., Palo Alto, CA 94304, 415/494-1165 ext. 1421)

• 26-28 International Symposium on Multiple-Valued Logic
Howard Johnsons, Boston, MA (Dan Simovici, University of Mass., Dept. of Computer Science, Boston, MA 02125, 617/929-7966)

• 27-29 Annual Frequency Control Symposium
Philadelphia, PA (R.L. Filler, US Army Electronics Technology and Devices Laboratory, SLCET-EQ, Ft. Monmouth, NJ 07703, 201/544-2467)

• 27-29 AEA Northeast Financial Conference
Boston, MA (Pamela A. Turner, American Electronics Association, 2670 Haonover St., P.O. Box 10045, Palo Alto, CA 94303, 415/857-9300)

• 28 Invitational Computer Conference-PC Reseller Series
Boston Marriott Newton, Newton, MA (Susie Ring, B.J. Johnson & Associates, Inc., 3151 Airway Ave., #C-2, Costa Mesa, CA 92626, 714/957-0171)

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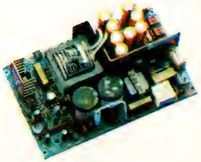
Why not?! From 45 to 500 watts, every open frame switching power supply in our new wide line meets VDE 0806 for safety. And all have a TUV logo on the side to show they've been approved to these precise VDE standards; not "designed to meet." Of course, none of this should surprise you. After all, every switcher we've introduced since 1983 meets VDE.

In addition, these power supplies all meet VDE 0871, Level A for conducted noise. Some even meet the more stringent Level B requirement, including the new "10 to 120KHz" standard.

Oh, since we got VDE, we figured we ought to get approvals for UL and CSA plus conform to FCC, IEC and other international regulatory agencies as well.

So if your product needs a power supply PDQ that meets VDE, UL, CSA, ETC., call ASAP. Sierra Power Systems (formerly Sierracin), 20500 Plummer Street, Chatsworth, California 91311. Call toll-free (800) 423-5569. In California, (818) 998-9873.



Sierra Power Systems
Division of Valor Electronics, Inc.

CIRCLE NO 59

EDN

CALENDAR OF
ELECTRONICS AND
COMPUTER INDUSTRY
EVENTS

June 1987

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
	1	**2**	**3**	**4**	**5**	**6**
7	**8**	**9**	**10**	**11**	**12**	**13**
14	**15**	**16**	**17**	**18**	**19**	**20**
21 FATHER'S DAY	**22**	**23**	**24**	**25**	**26**	**27**
28	**29**	**30**				

- **1-2 IFIP Workshop on CAD Engines**
  Kakaishinlou Kainkan, Japan (Prof. Tatsuo Ohtuski, Waseda University, Dept. of Elec. & Comm. School of Science & Engr., 3-4-2 Okubo, Shinjuku, Tokyo 160, Japan, 03-209-3211)
- **1-3 16th Annual Symposium on Incremental Motion Control Systems and Devices**
  Chancellor Hotel & Convention Center, Champaign, IL (Incremental Motion Control Systems Society, P.O. Box 2772, Station A, Champaign, IL 61820, 217/356-1523)
- **1-4 COMDEX/Spring**
  Georgia World Congress Center, Atlanta, GA (Linda M. Hanson, The Interface Group, Inc., 300 First Ave., Needham, MA 02194, 617/449-6600)
- **2-4 AUTOCOM '87**
  Hyatt Regency Dearborn, Dearborn, MI (Mark Kholos, Society of Manufacturing Engineers, One SME Drive, P.O. Box 930, Dearborn, MI 48121, 313/271-1500)
- **3-4 Network Management & Technology Conference & Exposition**
  Jacob K. Javits Convention Center, New York, NY (CW/Conference Management Group, 375 Cochituate Rd., Box 9171, Framingham, MA 01701, 617/879-0700)
- **3-5 ISHM Europe (European Microelectronics Conference and Exhibition)**
  Bournemouth, UK (Concorde Services, 10 Wendell Rd., London W12 9RT UK, 01-743-3106)
- **3-6 14th Int'l Symposium of Computer Architecture**
  Sheraton Station Square, Pittsburgh, PA (Zary Segall, Computer Science Dept., Carnegie Mellon University, Pittsburgh, PA 15213, 412/268-3736)
- **7-12 Summer Annual Meeting**
  Toronto, Canada (The American Society of Mechanical Engineers, United Engineering Center, 345 E. 47th St., New York, NY 10017, 212/705-7053)
- **8-11 International Conference on Computer Vision**
  London, England (Azriel Rosenfeld, University of Maryland, Center for Automation Research, College Park, MD 20742, 301/454-4526)
- **9-11 IEEE MTT-S International Microwave Symposium**
  Las Vegas, NV (Ferdo Ivanek, Harris Corp., 415/594-3529)
- **9-11 Nepcon East**
  Bayside Exposition Center & World Trade Center, Boston, MA (Janet Schafer, Cahners Exposition Group, 1350 E. Touhy Ave., Des Plaines, IL 60018, 312/299-9311)
- **9-11 VISION '87**
  Cobo Hall, Detroit, MI (Mark Kholos, Society of Manufacturing Engineers, One SME Drive, P.O. Box 930, Dearborn, MI 48121, 313/271-1500)
- **11-13 IEEE Workshop on Software Technology Transfer**
  LaFonda Hotel, Santa Fe, NM (Charles Richter, MCC, Software Tech. Prog., 9430 Research Blvd., Austin, TX 78759)
- **15-18 1987 National Computer Conference**
  McCormick Place, Chicago, IL (Michelle Conley, American Federation of Information Processing Societies, 1899 Preston White Drive, Reston, VA 22091, 703/620-8900)
- **15-19 ISDN**
  Atlanta, GA (Information Gatekeepers, 214 Harvard Ave., Boston, MA 02134, 617/232-3111)
- **16-18 North Central Lightwave Expo**
  Minneapolis, MN (Lightwave, 235 Bear Hill Rd., Waltham, MA 02154, 617/890-2700)
- **16-18 Sixth Canadian CAD/CAM & Robotics Conference & Exposition**
  International Centre, Toronto, Ontario, Canada (Mark Kholos, Society of Manufacturing Engineers, One SME Drive, P.O. Box 930, Dearborn, MI 48121, 313/271-1500)
- **16-18 41st AFCEA International Convention & Exposition**
  Washington, DC (The Armed Forces Communications and Electronics Association, 4400 Fair Lakes Court, Fairfax, VA 22033, 703/631-6125)
- **16-18 Scottish Technology Week and Conference**
  Scottish Exhibition Centre, Glasgow, Scotland (Cahners Exposition Group, P.O. Box 3833, Stamford, CT 06905, 203/964-0000)
- **17-18 Elexpo**
  Columbus, OH (Elexpo, Box 699, Utica, MI 48087, 313/254-5310)
- **17-19 NASECODE V Conference**
  Trinity College, Dublin, Ireland (Nasecode V, Conference Management Services, P.O. Box 5, 51 Sandycove Rd., Dun Laoghaire Co Dublin, Ireland, 353-1-808025)
- **22-26 LASER 87 Opto-Elektronik**
  Munich Trade Fair Center, Munich, Germany (Gerald G. Kallman, Kallman Associates, Five Maple Court, Ridgewood, NJ 07450, 201/652-7070)
- **23-25 Advanced Manufacturing Systems Exposition & Conference**
  McCormick Place, Chicago, IL (Cahners Exposition Group, P.O. Box 3833, Stamford, CT 06905, 203/964-0000)
- **23-25 ATE East**
  World Trade Center, Boston, MA (Steve Schuldenfrei, MG Expositions Group, 1050 Commonwealth Ave., Boston, MA 02215, 617/232-3976)
- **23-25 SAMPE Electronics Conference**
  Doubletree Inn, Santa Clara, CA (Marge Smith, Society for the Advancement of Material & Process Engineering, P.O. Box 2459, Covina, CA 91722, 818/331-0616)
- **24-26 SIGPLAN**
  St. Paul, Minnesota (S. Habib, CCNY, Computer Science, New York, NY 10031, 212/690-6631)
- **24-26 Int'l Conference on Computer Applications**
  Bejing, China (Dr. Tse-yun Feng, Penn State University, Elect. Eng. East Bldg., University Park, PA 16802)
- **24-26 SEMICON/Osaka**
  Intex Center, Osaka, Japan (Semiconductor Equipment and Materials Institute (SEMI), 415/964-5111)
- **24-July 1 24th ACM/IEEE Design Automation Conference**
  Miami Beach Conv. Ctr., Miami Beach, FL (P.O. Pistilli, MP Associates, 7366 Old Mill Trail, Boulder, CO 80301, 303/530-4562)
- **28-July 1 24th ACM/IEEE Design Automation Conference**
  Miami Convention Center, Miami, FL (Pat Pistilli, M.P. Associates, 7366 Old Mill Trail, Boulder, CO 80301, 303/530-4333)

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Only Airpax gives you real design freedom with VDE approved magnetic circuit breakers. From 50 milliamps to 50 amperes, in more than 50 configurations and styles. Only Airpax VDE approved breakers can help open your world markets. Airpax Corporation, Cambridge Division, Woods Road, Box 520, Cambridge, MD 21613. (301) 228-4600. A North American Philips Company.

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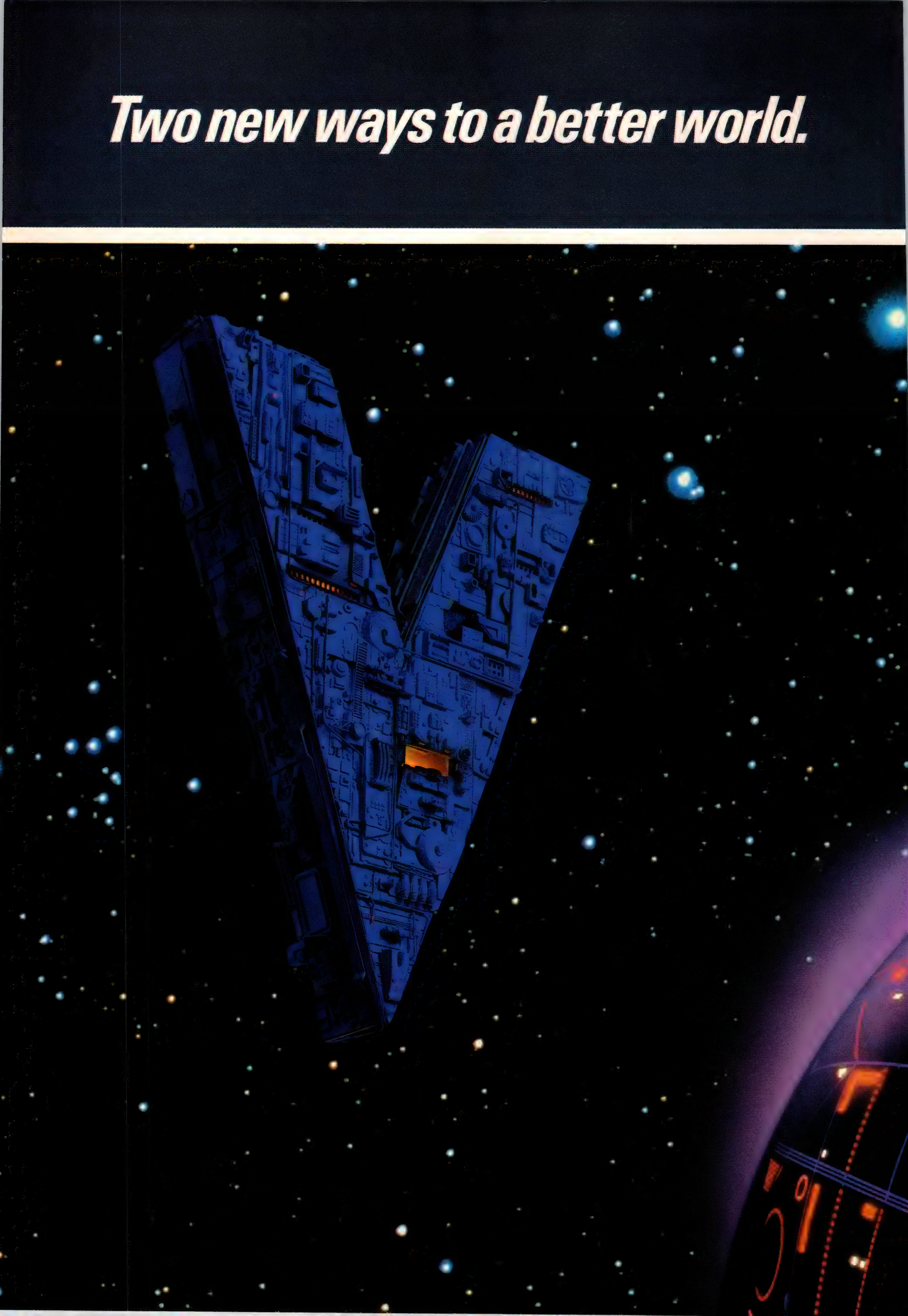
CAMBRIDGE DIVISION

CIRCLE NO 60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C&C
Computers and Communications

Introducing the economical V60 and the powerful V70. Two ways to succeed in the 32-bit realm.

Claim your share of the 32-bit future by picking the CMOS microprocessor that suits your system needs. Want economy? NEC's new V60 (16-bit external data bus) gives you an easy, affordable path into 32-bit products. Need performance? The V70 is a full 32-bit engine designed to power leading-edge systems.

SPEED.

V60/V70 supermicros offer a clock speed of 16MHz. They execute 3.5 MIPS and 6 MIPS respectively. And feature a six-stage pipelined CPU for concurrent execution of up to 4 instructions. There's no need to access slow off-chip memory. Because V60/V70 give you 32 on-board 32-bit general-purpose registers.

MULTI-TASKING, MULTI-USER.

The V60 and V70 feature an on-chip memory management unit with 4 gigabytes of demand-paged virtual memory space. And 4 levels of memory protection.

POWERFUL INSTRUCTION SET.

The V60/V70 instruction set is ideal for high-level languages and OS support (UNIX™ V and proprietary realtime OS). You get 21 addressing modes. 273 instructions. An emulation mode for 16-bit V20/V30 software. Greater programming flexibility. And new ease in generating optimized code.

Reader Vote No. 9001

COST EFFICIENT.

With its 16-bit data bus, V60 is the most economical design-in for 32-bit applications including; office automation, CAD/CAM workstations, time-sharing systems and realtime control.

NEC keeps costs down through innovative production techniques. V60/V70 are the densest CMOS microprocessors. And the first to integrate an MMU and basic floating-point processing functions on a single chip.

VISION.

V-Series microprocessors deliver more because they incorporate NEC's total computer, communications and components expertise. Join us in the 32-bit future by taking the road that suits you best. Price or performance. You'll find them both in the V-Series.

For further information, please contact:

■ USA	**Tel:415-960-6000. TWX: 910-379-6985**
■ Europe	**W. Germany** **Tel:0211-650302. Telex:8589960 NE D.**
	The Netherlands **Tel:040-445-845. Telex:51923 NEC B NL.**
	Sweden **Tel:08-732-8200. Telex:13839 NECSCAN.**
	France **Tel:1-3946-9617. Telex:699499 NEC EF.**
	Italy **Tel:02-6709108. Telex:315355 NEC EIT I.**
	UK **Tel:0908-691-133. Telex:826791 NEC UK G.**
■ Asia	**Hong Kong** **Tel:0-242-824. Telex:54561 HK NEC HX.**
	Taiwan **Tel:02-522-4192. Telex:22372 HK NEC TP.**
	Singapore **Tel:4819881. Telex:39726 NECSIN RS.**

NEC

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EDN

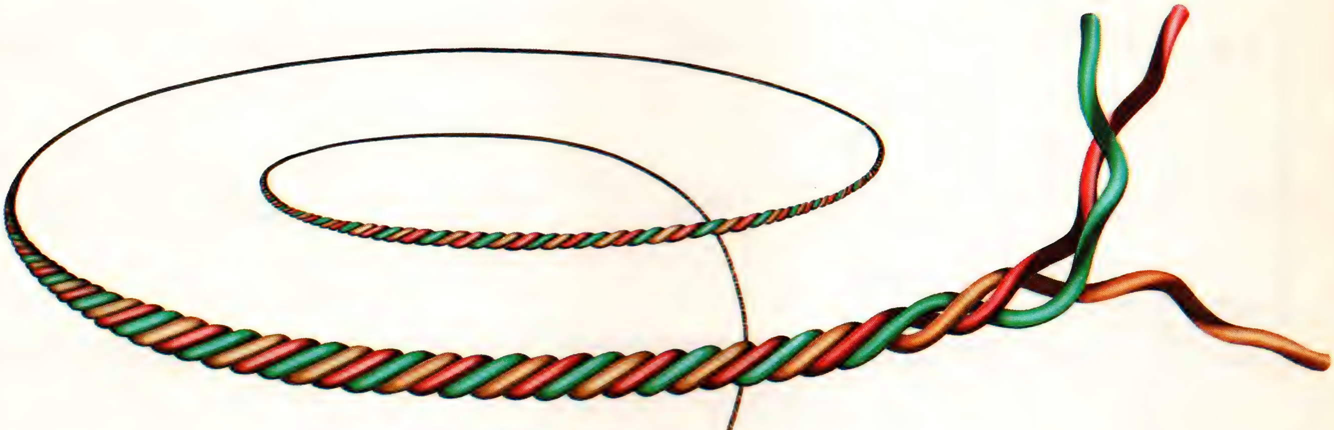
CALENDAR OF
ELECTRONICS AND
COMPUTER INDUSTRY
EVENTS

July 1987

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
			1	2	3	4 IND. DAY
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

- **1-4 Computer Assisted Radiology, Int'l Congress**
Berlin, West Germany (Michael L. Rhodes, 2730 Pacific Coast Hwy., Torrance CA 90505, 213/539-5944)
- **8-10 AUTOMACH AUSTRALIA '87**
Royal Agricultural Showgrounds, Sydney, Australia (Mark Kholos, Society of Manufacturing Engineers, One SME Drive, P.O. Box 930, Dearborn, MI 48121, 313/271-1500)
- **12-17 IEEE Power Engineering Society Summer Meeting**
Hilton Hotel & Tower, San Francisco, CA (K.D. Bailey, Bechtel National, P.O. Box 3965, San Francisco, CA 94119, 415/768-2372)
- **12-17 AEA/Santa Clara Management Development Program**
Santa Clara University, Santa Clara, CA (Mary Healy, American Electronicics Association, 2670 Hanover St., P.O. Box 10045, Palo Alto, CA 94303, 415/857-9300)
- **12-18 6th National Conference on Artificial Intelligence**
Seattle, WA (Lorraine Cooper, American Association for Artificial Intelligence, 445 Burgess Dr., Menlo Park, CA 94025, 415/328-3123)
- **13-15 Environmental Systems, Intersociety**
San Francisco, CA (The American Society of Mechanical Engineers, United Engineering Center, 345 E. 47th St., New York, NY 10017, 212/705-7053)
- **15-17 AEA California Financial Conference**
Monterey, CA (Pamela A. Turner, American Electronics Association, P.O. Box 10045, Palo Alto, CA 94303, 415/857-9300)
- **19-24 AEA Mid-Level Mfg. Management Program**
University of Santa Cruz Conference Center, Santa Cruz, CA (Mary Horngren Frost, American Electronics Association, 2670 Hanover St., P.O. Box 10045, Palo Alto, CA 94303, 415/857-9300)
- **24-27 Internepcon Malaysia**
Putra World Trade Centre, Kuala Lumpur, Malaysia (Cahners Exposition Group, P.O. Box 3833, Stamford, CT 06905, 203/964-0000)
- **27-29 Summer Computer Simulation Conference**
Montreal, Canada (The Society for Computer Simulation, P.O. Box 17900, San Diego, CA 92117, 619/277-3888)
- **27-31 Siggraph '87**
Anaheim Convention Center, Anaheim, CA (Robert J. Young, Mission Computer Associates, P.O. Box 2204, Mission Viejo, CA 92690, 714/830-5680)

Wind up with a new twist in twisted magnet wire.



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CIRCLE NO 55

EDN

CALENDAR OF
ELECTRONICS AND
COMPUTER INDUSTRY
EVENTS

August 1987

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23 30	24 31	25	26	27	28	29

- **2-14 AEA/Stanford Executive Institute**
Stanford University, Stanford, CA (Mary Horngren Frost, American Electronics Association, 2670 Hanover St., P.O. Box 10045, Palo Alto, CA 94303, 415/857-9300)
- **9-13 Intl. Computers in Engineering Conference and Exhibition**
New York, NY (The American Society of Mechanical Engineers, United Engineering Center, 345 E. 47th St., New York, NY 10017, 212/705-7053)
- **11 Basic IC Technology**
San Jose, CA (Pat Fruscello, Integrated Circuit Engineering Corp., 15022 N. 75th St., Scottsdale, AZ 85260, 602/998-9780)
- **11-13 Failure Avoidance/Analysis**
Denver, CO (Margaret DeRiso, DM Data Inc., 6900 E. Camelback Rd, Suite 1000, Scottsdale, AZ 85251, 602/945-9620)
- **12 Mid-Term '87**
San Jose, CA (Pat Fruscello, Integrated Circuit Engineering Corp., 15022 N. 75th St., Scottsdale, AZ 85260, 602/998-9780)
- **17-20 IXth International Conference on Production Research**
Netherland Plaza Hotel, Cincinnati, OH (Dr. Ernest L. Hall, Center for Robotics Research, University of Cincinnati, ML 72, Cincinnati, OH 45221)
- **17-20 NCGA's Engineering & Manufacturing '87**
Bayside Exposition Center, Boston, MA (Nancy A. Flower, National Computer Graphics Association, 2722 Merrilee Drive, Suite 200, Fairfax, VA 22031, 703/698-9600)
- **17-20 International Congress of Planning and Design Theory**
Boston, MA (The American Society of Mechanical Engineers, United Engineering Center, 345 E. 47th St., New York, NY 10017, 212/705-7053)
- **18 Basic IC Technology**
Scottsdale, AZ (Pat Fruscello, Integrated Circuit Engineering Corp., 15022 N. 75th St., Scottsdale, AZ 85260, 602/998-9780)
- **19 Mid-Term '87**
Scottsdale, AZ (Pat Fruscello, Integrated Circuit Engineering Corp., 15022 N. 75th St., Scottsdale, AZ 85260, 602/998-9780)
- **19-21 COMDEX/Australia**
RAS Showground, Sydney, Australia (Linda M. Hanson, 300 First Ave., Needham, MA 02194, 617/449-6600)
- **25 Basic IC Technology**
Boston, MA (Pat Fruscello, Integrated Circuit Engineering Corp., 15022 N. 75th St., Scottsdale, AZ 85260, 602/998-9780)
- **26 Mid-Term '87**
Boston, MA (Pat Fruscello, Integrated Circuit Engineering Corp., 15022 N. 75th St., Scottsdale, AZ 85260, 602/998-9780)
- **30-September 4 1987 Annual International Test Conference**
Sheraton Washington, Washington, DC (Doris Thomas, ITC, P.O. Box 264, Mt. Freedom, NJ 07970, 201/895-5260)

TIGHT SPECS FOR TIGHT SPACES

ABBOTT'S NEW 300-WATT SINGLE AND TRIPLE POWER SUPPLIES.

For design engineers who seek high-efficiency switching power supplies for use in the military environment—your ship has come in. Abbott introduces a new 300-watt switching power supply series which features tightly controlled and conservatively rated specs combined with an impressive 2.1 watts/cubic inch density (per NAVMAT guidelines).

Shipshape for powering naval sonar/radar, communications, ground support for airborne systems, and electronic counter measures equipment, the compact M300 accepts 115 V at 47 to 440 Hz input frequency. And it delivers 300 watts with very little ripple and noise as well as tight EMI specs. Its low 3" profile makes M300 perfect for new design applications, retrofit and modifications.

Standard features on every M300 power supply include short circuit protection and overvoltage protection. Plus every unit is encapsulated and hermetically sealed to meet the environmental requirements of MIL-STD-810C in addition to the 5-foot hammer drop of MIL-S-901C. All this makes M300 live up to our reputation "When reliability is imperative."®

For extra versatility, choose from a selection of optional features such as special connectors, three phase input, wider input voltage range, and wider operating temperature range. Plus, M300 is depot repairable for convenient routine maintenance operations.

Whenever you call for power, Abbott provides a powerful answer. Call or send for complete specifications today. Abbott Transistor® Laboratories, Inc., Power Supply Division, 5200 West Jefferson Blvd., Los Angeles, CA 90016 (213) 936-8185. Eastern Office: (201) 461-4411. Southwest Office: (214) 437-0697. London Office: 0737 82 3273.

ABBOTT M300 SWITCHING POWER SUPPLY SERIES

DIMENSIONS	***3" x 6" x 8"***
Input frequency	*47-440 Hz*
Input voltage	*115 V ac ±10%*
Output power	*300 watts*
Single	*(5V, 12V, 15V, 24 V, 28V)*
Triple	*(5V, ±12V, ±15V)*
Efficiency	*60% minimum*
Hold up time	*10 m Sec*
Ripple/noise	*100 mV peak-to-peak maximum*
Line regulation	*0.2% or 25 mV*
Load regulation	*0.2% or 25 mV*
EMI	*Meets MIL-STD-461B***
Environment	*Meets MIL-STD-810C, MIL-S-901C*
Input protection	*Per MIL-STD-1399*
Operating temperature range	*0°C to +71°C*
Storage temperature range	*−55°C to + 85°C*
MTBF (Ground benign)*	*>60,000 Hrs.*
ER option	*>134,000 Hrs.*
MTBF (Naval sheltered)*	*>11,000 Hrs.*
ER option	*>28,000 Hrs*

**MIL-HDBK-217D (50°C baseplate temp.)*
***Refer to spec sheet for applicable levels.*

WHEN RELIABILITY IS IMPERATIVE.®

abbott

MILITARY POWER SUPPLIES

CIRCLE NO 61

EDN

CALENDAR OF
ELECTRONICS AND
COMPUTER INDUSTRY
EVENTS

September 1987

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
		1	**2**	**3**	**4**	**5**
6	**7** LABOR DAY	**8**	**9**	**10**	**11**	**12**
13	**14**	**15**	**16**	**17**	**18**	**19**
20	**21**	**22**	**23**	**24**	**25**	**26**
27	**28**	**29**	**30**			

- **1-3 International Test Conference '87**
  Sheraton Washington Hotel, Washington, DC (IEEE Computer Society, IEEE Philadelphia Section, 201/895-5260)
- **1-3 PC EXPO**
  Jacob K. Javits Convention Center, New York, NY (Annie Zdinak, PC Expo, 333 Sylvan Ave., Englewood Cliffs, NJ 07632, 800/922-0324)
- **2-5 Internepcon/Semiconductor International Hong Kong**
  Ocean Terminal, Kowloon, Hong Kong (Cahners Exposition Group, P.O. Box 3833, Stamford, CT 06905, 203/964-0000)
- **2-5 CEX: International Electronics Components & Equipment Exhibition**
  Ocean Terminal, Kowloon, Hong Kong (Cahners Exposition Group, P.O. Box 3833, Stamford, CT 06905, 2-03/964-0000)
- **8-13 Telecomp China 87**
  Beijing/China International Exhibition Centre (Gerald G. Kallman, Kallman Associates, Five Maple Court, Ridgewood, NJ 07450, 201/652-7070)
- **9-11 Modern Electronic Packaging**
  Seattle, WA (Technology Seminars, Box 487, Lutherville, MD 21093, 301/269-4102)
- **10 Invitational Computer Conference-Computer Graphic Series**
  Pier 66, Ft. Lauderdale, FL (Susie Ring, B.J. Johnson & Associates, Inc., 3151 Airway Ave., #C-2, Costa Mesa, CA 92626, 714/957-0171)
- **14-18 7th Int'l Conference on Distributed Computing Systems**
  Hotel Intercontinental, Berlin, Germany (Herbert Weber, Univeersitat Dortmund, Fachbereich Informatik, 46 Dortmund 50, Postfach 50 05 00, 0231/755-1)
- **15-17 Failure Avoidance/Analysis**
  Monrovia, CA (Margaret DeRiso, DM Data Inc., 6900 E. Camelback Rd, Suite 1000, Scottsdale, AZ 85251, 602/945-9620)
- **15-17 PC Fab Expo '87**
  Radisson Hotel South, Minneapolis, MN (PMS Industries, 1790 Hembree Road, Alpharetta, GA 30201, 404/475-1818)
- **15-17 Automated Design and Engineering for Electronics (ADEE) East**
  World Trade Center, Boston, MA (Cahners Exposition Group, 312/299-9311)
- **15-17 Midcon/87**
  O'Hare Exposition Center, Rosemont, IL (Alexes Razevich, Electronic Conventions Management, 8110 Airport Boulevard, Los Angeles, CA 90045, 213/772-2965)
- **18 The Cost Edge**
  Ontario, CA (Margaret DeRiso, DM Data Inc., 6900 E. Camelback Rd, Suite 1000, Scottsdale, AZ 85251, 602/945-9620)
- **21-24 1987 Conference on Software Maintenance**
  Austin, TX (Roger Martin, National Bureau of Standards, Bldg. 225, Room B266, Gaithersburg, MD 20899, 301/921-3545)
- **22 Semiconductor Packaging**
  Boston, MA (Pat Fruscello, Integrated Circuit Engineering Corp., 15022 N. 75th St., Scottsdale, AZ 85260, 602/998-9780)
- **22 Electronic Packaging**
  IEEE Videoconferences, Seminars via Satellite (IEEE Continuing Education Dept., 445 Hoes Lane, Piscataway, NJ 08854, 201/981-0060)
- **22-23 BUSCON/87-East**
  Nassau Coliseum, Long Island, NY (Anne Weber, MultiDynamics, Inc., 17100 Norwalk Blvd., Suite 116, Cerritos, CA 90701, 213/402-1610)
- **22-23 SYSCON/87-East**
  Nassau Coliseum, Long Island, NY (Anne Weber, MultiDynamics, Inc., 17100 Norwalk Blvd., Suite 116, Cerritos, CA 90701, 213/402-1610)
- **22-24 SEMICON/East**
  Bayside Exposition Center, Boston, MA (Semiconductor Equipment and Materials Institute (SEMI), 415/964-5111)
- **22-24 Northcon/87**
  Portland Memorial Coliseum, Portland, OR (Alexes Razevich, Electronic Conventions Management, 8110 Airport Boulevard, Los Angeles, CA 90045, 213/772-2965)
- **22-25 European Electronics for National Security Show**
  Palazzo Dei Congressi, Rome, Italy (Cahners Exposition Group, P.O. Box 3833, Stamford, CT 06905, 203/964-0000)
- **23-25 Practical IC Fabrication**
  Boston, MA (Pat Fruscello, Integrated Circuit Engineering Corp., 15022 N. 75th St., Scottsdale, AZ 85260, 602/998-9780)
- **24 Invitational Computer Conference-PC Reseller Series**
  Frankfurt Sheraton Hotel, Frankfurt, West Germany (Susie Ring, B.J. Johnson & Associates, Inc., 3151 Airway Ave., #C-2, Costa Mesa, CA 92626, 714/957-0171)
- **27-30 Design Automation Conference**
  Boston, MA (The American Society of Mechanical Engineers, United Engineering Center, 345 E. 47th St., New York, NY 10017, 212/705-7053)
- **28-October 1 OCEANS'87**
  World Trade and Convention Center, Halifax, Nova Scotia, Canada (Joseph H. Seiler, 902/835-9686)
- **28-October 1 NCGA's Computer Publishing '87**
  San Francisco Civic Auditorium, San Francisco, CA (Nancy A. Flower, National Computer Graphics Association, 2722 Merrilee Drive, Suite 200, Fairfax, VA 22031, 703/698-9600)
- **29-30 Nepcon Southwest**
  Dallas InfoMart, Dallas, TX (Dennis Stanczak, Cahners Exposition Group, 1350 E. Touhy Ave, Des Plaines, IL 60018, 312/299-9311)
- **29-October 1 Fall National Design Engineering Conference and Show**
  New York, NY (The American Society of Mechanical Engineers, United Engineering Center, 345 E. 47th St., New York, NY 10017, 212/705-7053)
- **29-October 2 New York Information Management Exposition and Conference**
  Jacob Javits Convention Center, New York, NY (Cahners Exposition Group, 203/964-0000)

MORE BANG. LESS BUCK.

Why weapons systems designers are using Rantec standard military power supplies.

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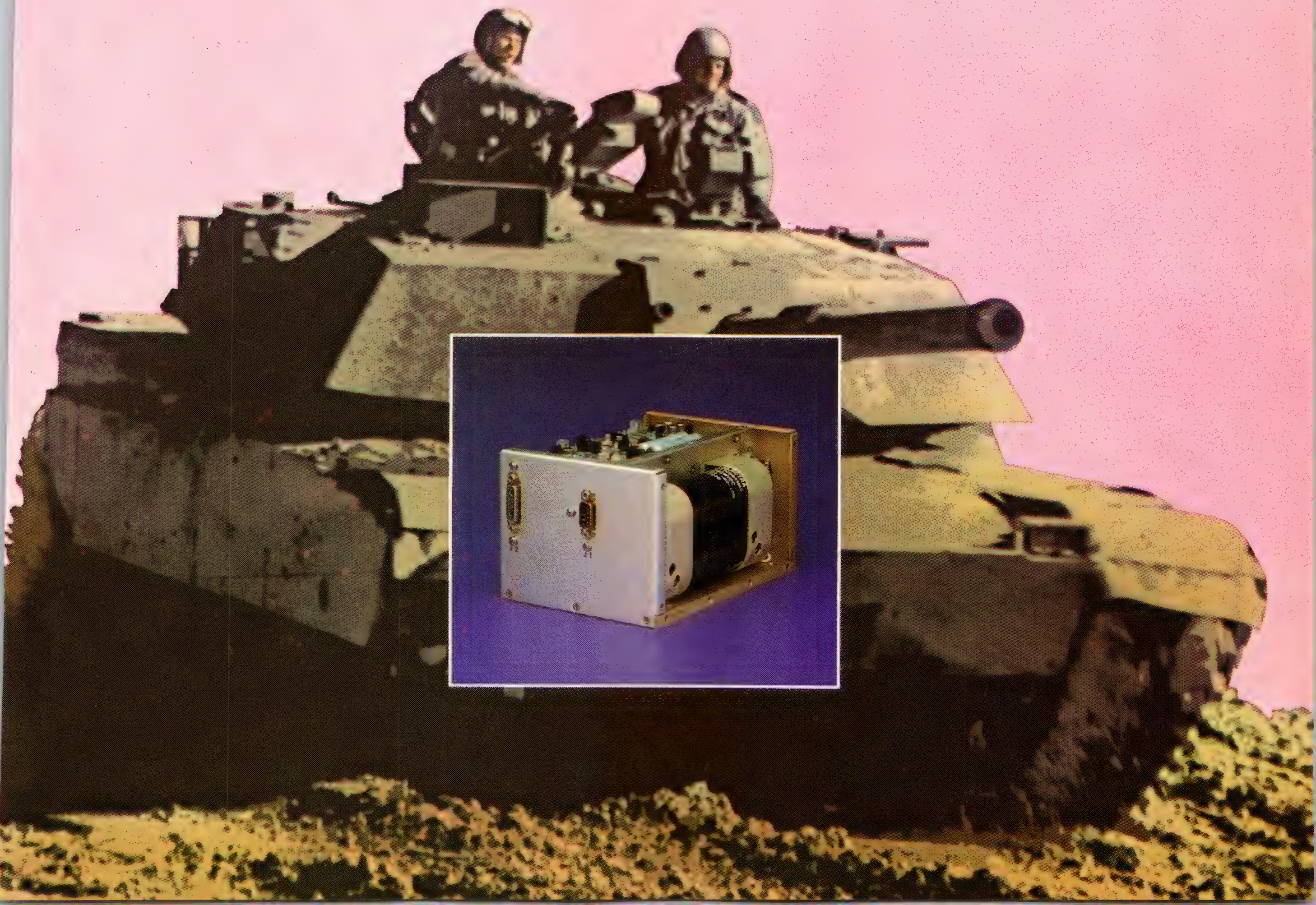
*U.S. Navy/Industry Power Supply Ad Hoc Committee Estimates for Time and Cost.



EDN

CALENDAR OF
ELECTRONICS AND
COMPUTER INDUSTRY
EVENTS

October 1987

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
				1	2	3 YOM KIPPUR
4	5	6	7	8	9	10
11	12 COLUMBUS DAY	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31 HALLOWEEN

- **1 Invitational Computer Conference-PC Reseller Series**
  Hyatt at L.A. Airport, Los Angeles, CA (Susie Ring, B.J. Johnson & Associates, Inc., 3151 Airway Ave., #C-2, Costa Mesa, CA 92626, 714/957-0171)
- **1 Invitational Computer Conference-Computer Graphic Series**
  Boston Marriott Newton, Newton, MA (Susie Ring, B.J. Johnson & Associates, Inc., 3151 Airway Ave., #C-2, Costa Mesa, CA 92626, 714/957-0171)
- **2 Invitational Computer Conference-PC Reseller Series**
  Madrid, Spain (Susie Ring, B.J. Johnson & Associates, Inc., 3151 Airway Ave., #C-2, Costa Mesa, CA 92626, 714/957-0171)
- **4-7 IPC Fall Semi-Annual Meeting**
  Chicago Marriott Downtown, Chicago, IL (Anthony Hilvers, The Institute for Interconnecting and Packaging Electronic Circuits, 7380 Lincoln Ave., Lincolnwood, IL 60646, 312/677-2850)
- **4-8 Joint Power Generation Conference**
  Omni Marriott Hotel, Miami, FL (C.R. Pope, Philadelphia Electric Co., 2301 Market St., Philadelphia, PA 19101, 215/841-4603)
- **5-8 2nd Int'l Conference on Architectural Support for Programming Languages**
  Palo Alto, CA (Martin Freeman, Signetics Corp., 811 E. Arques Ave., P.O. Box 3409, Sunnyvale, CA 94088)
- **7-8 TEXCON**
  Wyndham Hotel, Austin, TX (Anne Weber, MultiDynamics, Inc., 17100 Norwalk Blvd., Suite 116, Cerritos, CA 90701, 213/402-1610)
- **11-16 COMPSAC '87**
  Americana Congress Hotel, Chicago, IL (IEEE Computer Society, 1730 Massachusetts Ave., NW, Washington, DC 20036, 202/371-0101)
- **12-15 Infomatocs 87**
  Vienna, Austria (Don M. Avedon, International Information Management Congress, 301/983-0604)
- **12-16 FOCS**
  Marina Beach Hotel, Los Angeles, CA (Ashok Chandra, IBM T.J. Watson Research Ctr., P.O. Box 218, Yorktown Heights, NY 10598, 914/945-1752)
- **13 Invitational Computer Conference-Computer Graphic Series**
  Irvine Hilton & Towers, Irvine, CA (Susie Ring, B.J. Johnson & Associates, Inc., 3151 Airway Ave., #C-2, Costa Mesa, CA 92626, 714/957-0171)
- **13-15 19th International SAMPE Technical Conference**
  Hyatt Hotel, Arlington, VA (Marge Smith, Society of the Advancement of Material & Process Engineering, P.O. Box 2459, Covina, CA 91722, 818/331-0616)
- **13-15 Failure Avoidance/Analysis**
  Washington, DC (Margaret DeRiso, DM Data Inc., 6900 E. Camelback Rd, Suite 1000, Scottsdale, AZ 85251, 602/945-9620)
- **13-15 PC EXPO**
  McCormick Place North, Chicago, IL (Annie Zdinak, PC Expo, 333 Sylvan Ave., Englewood Cliffs, NJ 07632, 800/922-0324)
- **14-15 BUSCON International/UK**
  The Excelsior Hotel, Heathrow, England (Anne Weber, MultiDynamics, Inc., 17100 Norwalk Blvd., Suite 116, Cerritos, CA 90701, 213/402-1610)
- **14-15 The Power Electronics Conference/87-West**
  Los Angeles Airport Hilton Hotel, Los Angeles, CA (Anne Weber, MultiDynamics, Inc., 17100 Norwalk Blvd., Suite 116, Cerritos, CA 90701, 213/402-1610)
- **14-15 SEMICON/Southwest**
  Infomart, Dallas, TX (Semiconductor Equipment and Materials Institute (SEMI), 415/964-5111)
- **14-16 ULTRATECH Conference & Expositions**
  Long Beach Convention & Entertainment Center, Long Beach, CA (Mark Kholos, Society of Manufacturing Engineers, One SME Drive, P.O. Box 930, Dearborn, MI 48121, 313/271-1500)
- **14-16 IEEE Professional Communication Society International Conference**
  Sheraton-Winnipeg, Winnipeg, Canada (Ron S. Blicq, The Roning Group, Box 181, Postal Station C, Winnipeg, MB Canada, R3M 3S7, 204/632-2292)
- **15 Invitational Computer Conference-PC Reseller Series**
  Crowne Plaza Hotel, Dallas, TX (Susie Ring, B.J. Johnson & Associates, Inc., 3151 Airway Ave., #C-2, Costa Mesa, CA 92626, 714/957-0171)
- **16 The Cost Edge**
  Washington, DC (Margaret DeRiso, DM Data Inc., 6900 E. Camelback Rd, Suite 1000, Scottsdale, AZ 85251, 602/945-9620)
- **18-22 International Conference on Computer Design**
  Bally's Park Place, Atlantic City, NJ (IEEE Computer Society, 1730 Massachusetts Ave., NW, Washington, DC 20036, 202/371-0101)
- **19-21 20th Annual Connectors and Interconnection Technology Symposium**
  Franklin Plaza Hotel, Philadelphia, PA (Electronic Connector Study Group, P.O. Box 167, Fort Washington, PA 19034, 215/825-3840)
- **19-22 Joint IEEE/CSEE Conference on High-Voltage Transmission Systems in China**
  Beijing, People's Republic of China (L.O. Barthold, Power Technologies, Inc., P.O. Box 1058, Schenectady, NY 12301, 518-374-1220)
- **19-22 IEEE Military Communications Conference (MILCOM '87)**
  McLean Hilton, McLean, VA (Alan J. Roberts, 703/883-5691)
- **19-23 SYSTEMS 87**
  Munich Trade Fair Centre, Munich, Germany (Gerald G. Kallman, Kallman Associates, Five Maple Court, Ridgewood, NJ 07450, 201/652-7070)
- **20-21 Failure Analysis Avoidance**
  Scottsdale, AZ (Pat Fruscello, Integrated Circuit Engineering Corp., 15022 N. 75th St., Scottsdale, AZ 85260, 602/998-9780)
- **20-22 Nepcon Northwest**
  Santa Clara Expo Center, Santa Clara, CA (Jerry Carter, Cahners Exposition Group, 1350 E. Touhy Ave., Des Plaines, IL 60018, 312/299-9311)
- **20-23 Service Company Executives Forum**
  San Diego, CA (Mary Harrington, Association for Information and Image Management, 1100 Wayne Ave., Suite 1100, Silver Spring, MD 20910, 301/587-8202)
- **20-27 Telecom '87**
  USA Pavillion, Geneva, Switzerland (Henry Wieland, Jr., U.S. Telephone Assoc. and US. Telecommunications Suppliers Assoc., 900 19th St., NW, Suite 800, Washington, DC 20006, 202/835-3162)
- **21-22 Network Management & Technology Conference & Exposition**
  Expocenter at the Merchandise Mart, Chicago, IL (CW/Conference Management Group, 375 Cochituate Rd., Box 9171, Framingham, MA 01701-9171, 617/879-0700)
- **21-23 8th AFCEA European Symposium & Exposition**
  Brussels Sheraton Hotel, Brussels, Belgium (The Armed Forces Communications and Electronics Association, 4400 Fair Lakes Court, Fairfax, VA 22033, 703/631-6125)
- **25-28 Industrial Power Conference**
  Atlanta, GA (The American Society of Mechanical Engineers, United Engineering Center, 345 E. 47th St., New York, NY 10017, 212/705-7053)
- **25-29 ACM/Computer Society of IEEE FJCC**
  Dallas, TX (IEEE Computer Society, 1730 Massachusetts Ave., NW, Washington, DC 20036, 202/371-0101)

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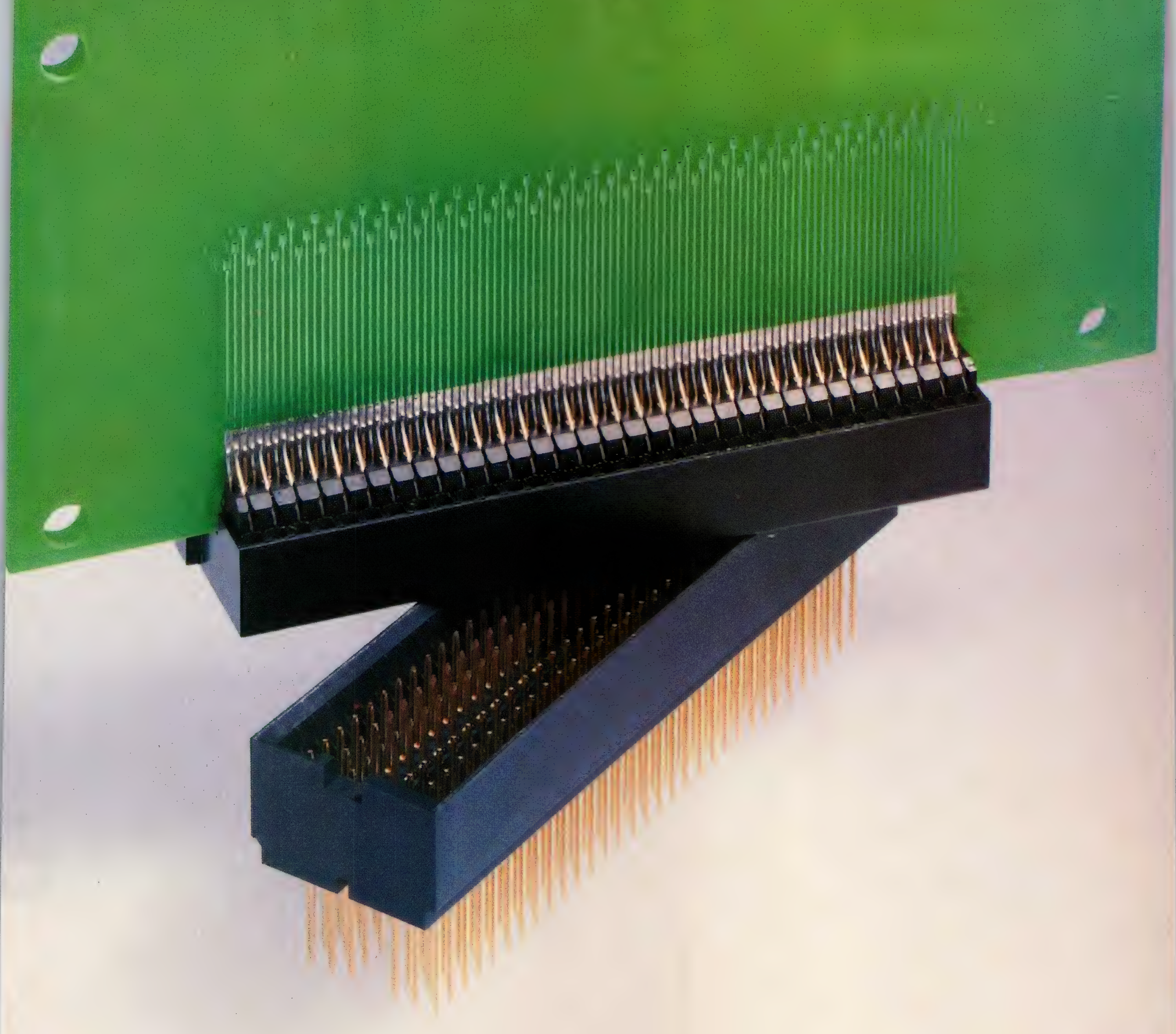

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*Patent Pending

ELFAB
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CIRCLE NO 62

FROM EARTH

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Now Voyager is hurtling towards its next scheduled rendezvous—with Neptune, nearly 2.7 billion miles from home. After that, this extension of our civilization will head for the edge of the solar system.

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TO ETERNITY.

Series logic and RAMS from RCA are helping to make this historic voyage possible. And we are confident that the unsurpassed reliability of RCA High-Rel integrated circuits will help to keep Voyager on course for years to come.

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GE RCA

Reader Vote No. 9002

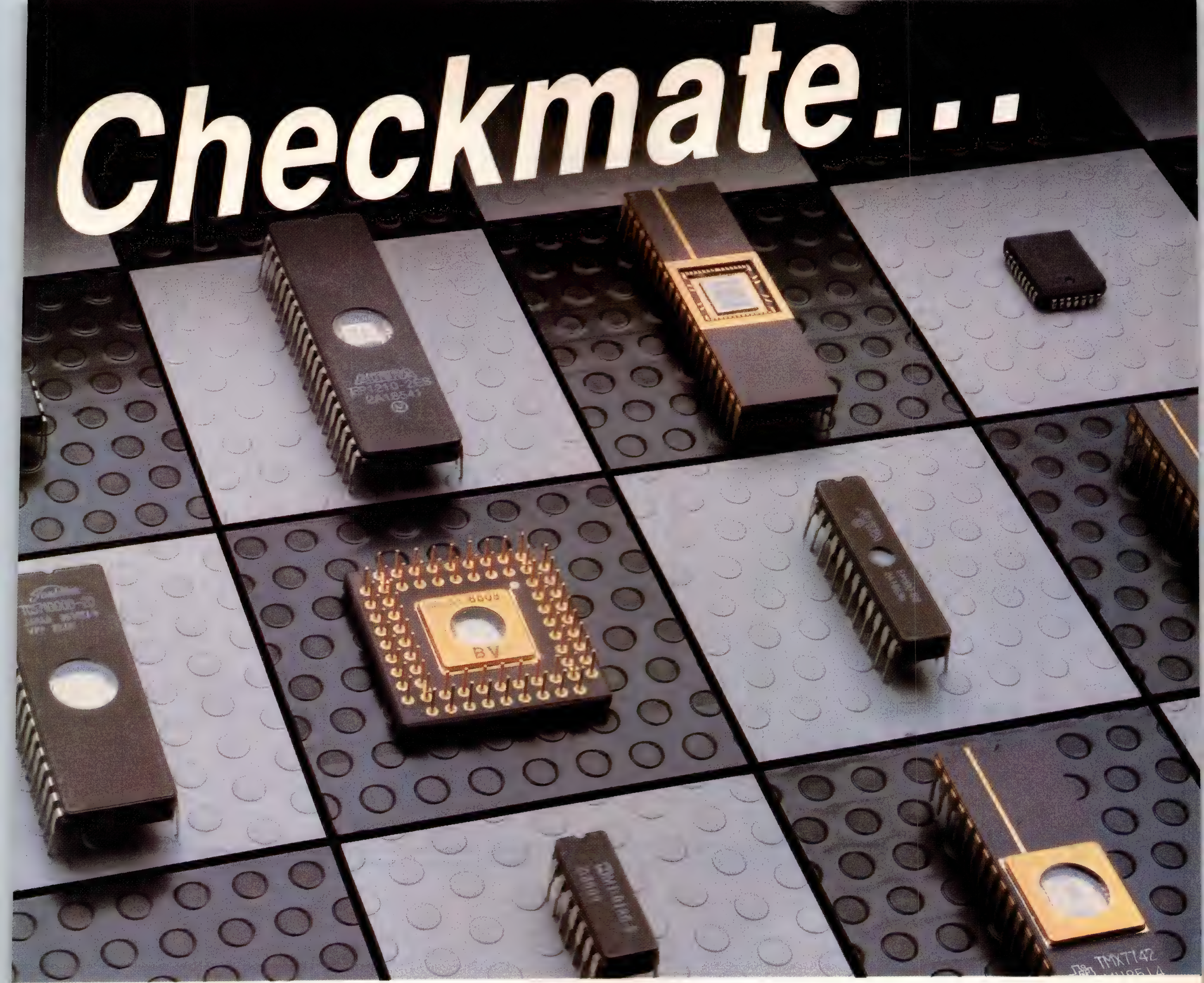
EDN

CALENDAR OF
ELECTRONICS AND
COMPUTER INDUSTRY
EVENTS

November 1987

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
1	**2**	**3** ELECTION DAY	**4**	**5**	**6**	**7**
8	**9**	**10**	**11** VETERAN'S DAY	**12**	**13**	**14**
15	**16**	**17**	**18**	**19**	**20**	**21**
22	**23**	**24**	**25**	**26** THANKSGIVING DAY	**27**	**28**
29	**30**					

- **2-4 Modern Electronic Packaging**
  Burlington, MA (Technology Seminars, Box 487, Lutherville, MD 21093, 301/269-4102)
- **2-6 AEA/Santa Clara Management Development Program**
  Santa Clara University, Santa Clara, CA (Mary Healy, American Electronics Association, 2670 Hanover St., P.O. Box 10045, Palo Alto, CA 94303, 415/857-9300)
- **2-6 COMDEX/Fall**
  Las Vegas Convention Center, West Hall, Las Vegas Hilton, Caesar's Palace, Bally's Las Vegas, Riviera and Sahara Hotels, Las Vegas, NV (Linda M. Hanson, 300 First Ave., Needham, MA 02194, 617/449-6600)
- **3-5 AUTOTESTCON '87**
  Moscone Convention Center, San Francisco, CA (Mr. Ted Parker, 805/482-0757)
- **3-5 Electronic Imaging East**
  World Trade Center, Boston, MA (Steve Schuldenfrei, MG Expostions Group, 1050 Commonwealth Ave., Boston, MA 02215, 617/232-3976)
- **4-6 SEMICON/Korea**
  Korea Exhibition Center, Seoul, Korea (Semiconductor Equipment and Materials Institute (SEMI) 415/964-5111)
- **5-6 Seminar on Strategies for Successful Marketing in the Technology Industries**
  Marriott Burlington Hotel, Burlington, MA (Technology Seminars, 301/269-4102)
- **9-12 AUTOFACT '87 Conference & Exposition**
  Cobo Hall, Detroit, MI (Mark Kholos, Society of Manufacturing Engineers, One SME Drive, P.O. Box 930, Dearborn, MI 48121, 313/271-1500)
- **9-12 IEEE International Conference on Computer Aided Design**
  Santa Clara Convention Center, Santa Clara, CA (Basant Chawla, AT&T Bell Laboratories, 1247 S. Cedar Crest Blvd., Allentown, PA 18103, 215/770-3485)
- **9-13 MONTECH '87**
  Palais de Congres, Montreal, Canada (Donald T. McGilles, 514/289-5054)
- **10-14 Productronica 87**
  Munich Trade Fair Centre, Munich, Germany (Gerald G. Kallman, Kallman Associates, Five Maple Court, Ridgewood, NJ 07450, 201/652-7070)
- **12-14 Principles of RF and Microwave Circuit Design**
  Laurel, MD (Besser Associates, 3975 E. Bayshore Rd., Palo Alto, CA 94303, 415/969-3400)
- **15-18 GLOBECOM '87**
  Keio Plaza Inter-continental Hotel, Tokyo, Japan (Noriyoshi Kuroyanagi, 81-422-59-2539)
- **16-20 Salon International des Composants Electroniques '87**
  Parc d'Expositions, Paris, France (Societe pour la diffusion des sciences et des arts (SDSA), 202/377-5014)
- **17-19 Failure Avoidance/Analysis**
  Monrovia, CA (Margaret DeRiso, DM Data Inc., 6900 E. Camelback Rd, Suite 1000, Scottsdale, AZ 85251, 602/945-9620)
- **17-19 Wescon/87**
  Moscone Center, San Francisco, CA (Alexes Razevich, Electronic Conventions Management, 8110 Airport Boulevard, Los Angeles, CA 90045, 213/772-2965)
- **18-20 Practical IC Fabrication**
  San Jose, CA (Pat Fruscello, Integrated Circuit Engineering Corp., 15022 N. 75th St., Scottsdale, AZ 85260, 602/998-9780)
- **18-21 PRONIC 86**
  Porte de Versailles Exhibition Grounds, Paris, France (Societe pour la diffusion des sciences et des arts (SDSA), 011-33-1-505-1317)



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CIRCLE NO 63

EDN

CALENDAR OF
ELECTRONICS AND
COMPUTER INDUSTRY
EVENTS

December 1987

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25 CHRISTMAS DAY	26
27	28	29	30	31		

• **2 Micro Contamination Control**
IEEE Videoconferences, Seminars via Satellite (IEEE Continuing Education Dept., 445 Hoes Lane, Piscataway, NJ 08854, 201/981-0060)

• **2-4 SEMICON/Japan**
Tokyo International Trade Center, Tokyo, Japan (Semiconductor Equipment and Materials Institute (SEMI), 415/964-5111)

• **6-9 1987 IEEE International Electron Devices Meeting**
Washington Hilton, Washington, DC (Ms. Melissa Widekehr, 202/347-5900)

• **9-11 1987 26th IEEE Conference on Decision and Control**
Century Plaza Hotel, Los Angeles, CA (William S. Levine, 301/454-6841)

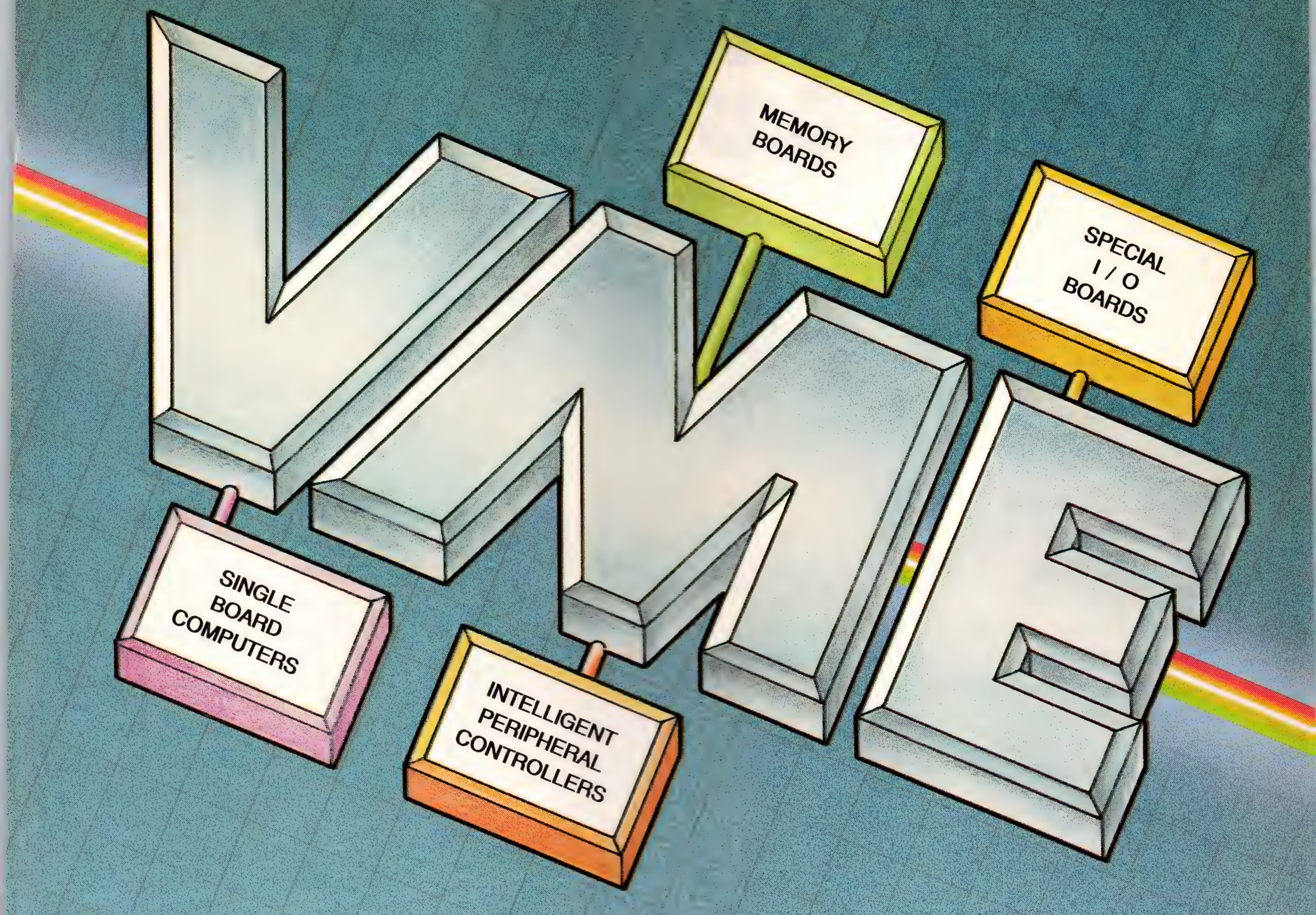
• **9-11 Winter Simulation Conference**
Location TBA (ACM Conference Dept., 11 W. 42nd St., New York, NY 10036, 212/869-7440)

• **11-13 INTERFACE in JAPAN**
Harumi Exhibition Center and Keio Plaza Hotel, Tokyo, Japan (The Interface Group Inc., 616/449-6600)

• **14-18 12th Annual IEEE International Conference on Infrared and Millimeter Waves**
Americana Dutch Resort Hotel, Orlando, FL (Kenneth J. Button, 617/253-5561)

• **15-17 Principles of RF and Microwave Circuit Design**
Santa Clara, CA (Besser Associates, 3975 E. Bayshore Rd., Palo Alto, CA 94303, 415/969-3400)

• **15-17 Winter National Design Engineering Conference and Show**
Anaheim, CA (The American Society of Mechanical Engineers, United Engineering Center, 345 E. 47th St., New York, NY 10017, 212/705-7053)



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CIRCLE NO 64

SILICON SYSTEMS— INNOVATORS IN INTEGRATION

Gary Kelson
Senior Vice President, Chief Technical Officer

Demonstrated Leadership in Combining Analog and Digital Designs on a Single Chip, and Offering Both CMOS and Bipolar Processing in Our Own Advanced Wafer Fab.

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Silicon Systems is years ahead of the competition in the design of custom and semicustom analog, digital, and combined analog/digital IC's in Bipolar and CMOS technologies. One reason for this success is our heavy investments in the most advanced computer-aided design system called IDM— Integrated Design Methodology. This proprietary design tool is the ultimate solution for supporting our customers' requirements. IDM allows auto-routed cells, compiled macros, and full custom circuitry to be intermixed on a single chip. The result: IDM provides faster turnaround, lower cost, and higher performance while eliminating design errors.

This design "edge" has led us into a broad diversity of design applications. However, we aren't resting on our laurels. With a dedicated design automation team with 14 years of experience, we are defining the state-of-the-art for future analog and analog/digital design methodologies. Furthermore, our systems engineering background allows Silicon Systems to live up to its name by providing true systems on a chip performance, thereby affording our customers a true competitive advantage.

PROCESS EXPERTISE

But there's more to a great IC company than just great design. And that's why Silicon Systems developed a multi-process wafer fab running advanced CMOS and Bipolar technologies optimized for ASIC development and production.

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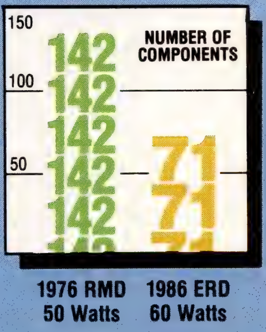
Career Information, Circle No. 51

silicon systems™
INNOVATORS IN INTEGRATION

Product Information, Circle No. 52

WHAT'S THE DIFFERENCE BETWEEN 1976 AND 1986?

This . . .



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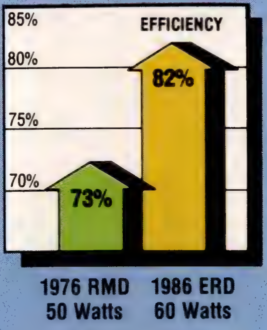

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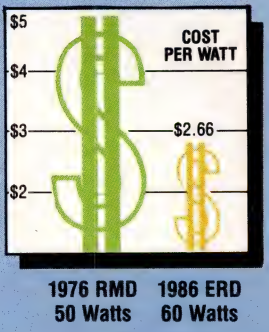

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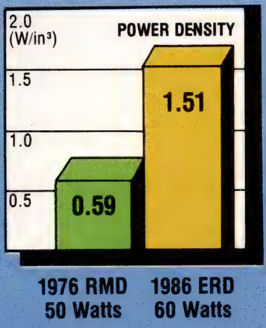

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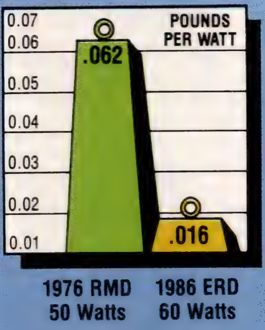

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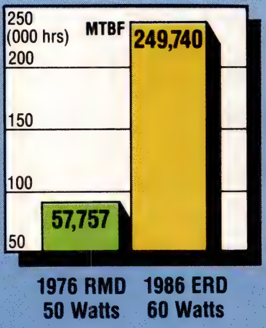

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We're offering Series ERD d-c to d-c converters in three sizes: 30 Watts, 60 Watts, and 150 Watts; 10 models are available in each size: 5V-, 12V-, 15V-, 24V-, and 48V-output.

These d-c to d-c converters are offered with either 24V inputs or 48V inputs — 30 models in all.

Single unit prices: 30 Watts, $135; 60 Watts, $160; 150 Watts, $225.

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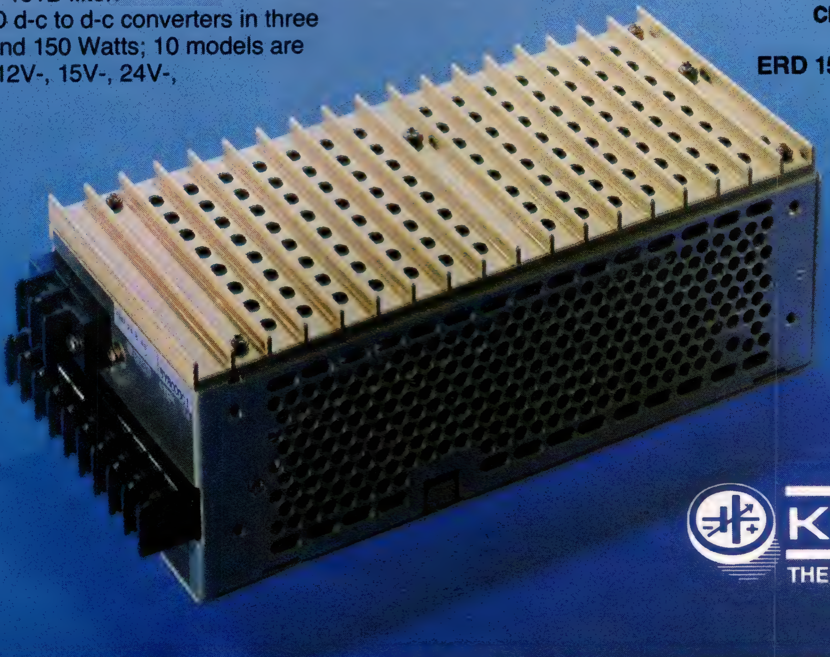
CIRCLE NO 127

ERD 150 WATT MODEL



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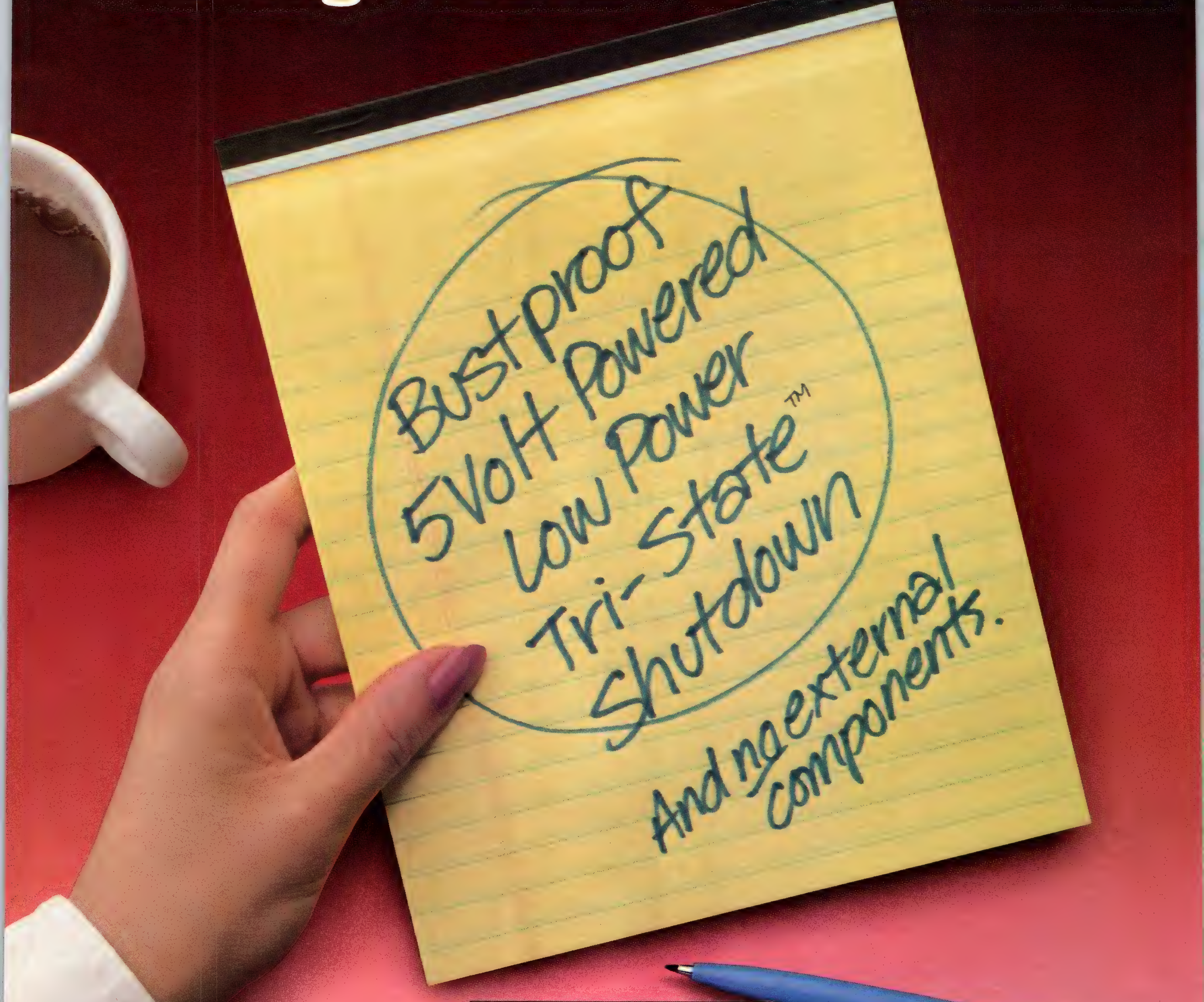

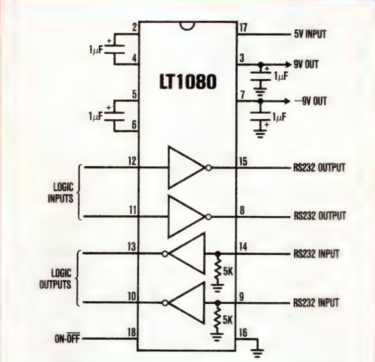

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CIRCLE NO 128

DESIGN IDEAS

EDITED BY TARLTON FLEMING

EPROM enhances TMS32010 µC's memory

Robert M Sovacool
General Motors, Warren, OH

Available memory can be a problem when developing signal-processing applications for the TMS32010 µC. The µC contains 4k 2-byte words of program memory and 144 2-byte words of data memory. You can store data tables in the remaining program space after you've developed the application program, but your tables may require more space than that.

The circuit in **Fig 1** uses a 16k×8-bit EPROM and some of the 32010's eight I/O channels to provide 8k 2-byte words of data space. By writing an OUT instruction to the proper I/O address, you load the initial table address into the 14-bit counter IC_5-IC_8. Decoder IC_2 strobes this address into the counter. Allowing a delay for the memory's maximum settling time, your program writes a series of IN instructions to another I/O address, which fetches data words from the EPROM via buffer IC_9, one byte at a time. At the end of each IN instruction, the OR gate IC_4 automatically bumps the counter by one count to access the EPROM's next byte of data.

EPROMs with access times of 70 nsec or less will allow the program to fetch data in response to consecutive instructions; 250-nsec EPROMs allow a fetch on every other instruction. Because the upper half of the data bus floats between read operations, the alternate instruction (between IN instructions) can be a software AND, which clears the high byte to zero. Or you can strobe zeros into the high byte using an additional buffer with inputs tied to ground and free the time interval between IN instructions for another DSP instruction.

Furthermore, you can eliminate data-bus connections to the counter if you don't need to preload it with a nonzero address. In such a case, invert IC_2's output and connect it to the counter's reset input. As another option, your system can access dual EPROMs in parallel, fetching a 16-bit word during each read operation. The arrangement requires storage of even and odd bytes in separate EPROMs; many EPROM programmers can handle this requirement. **EDN**

To Vote For This Design, Circle No 750

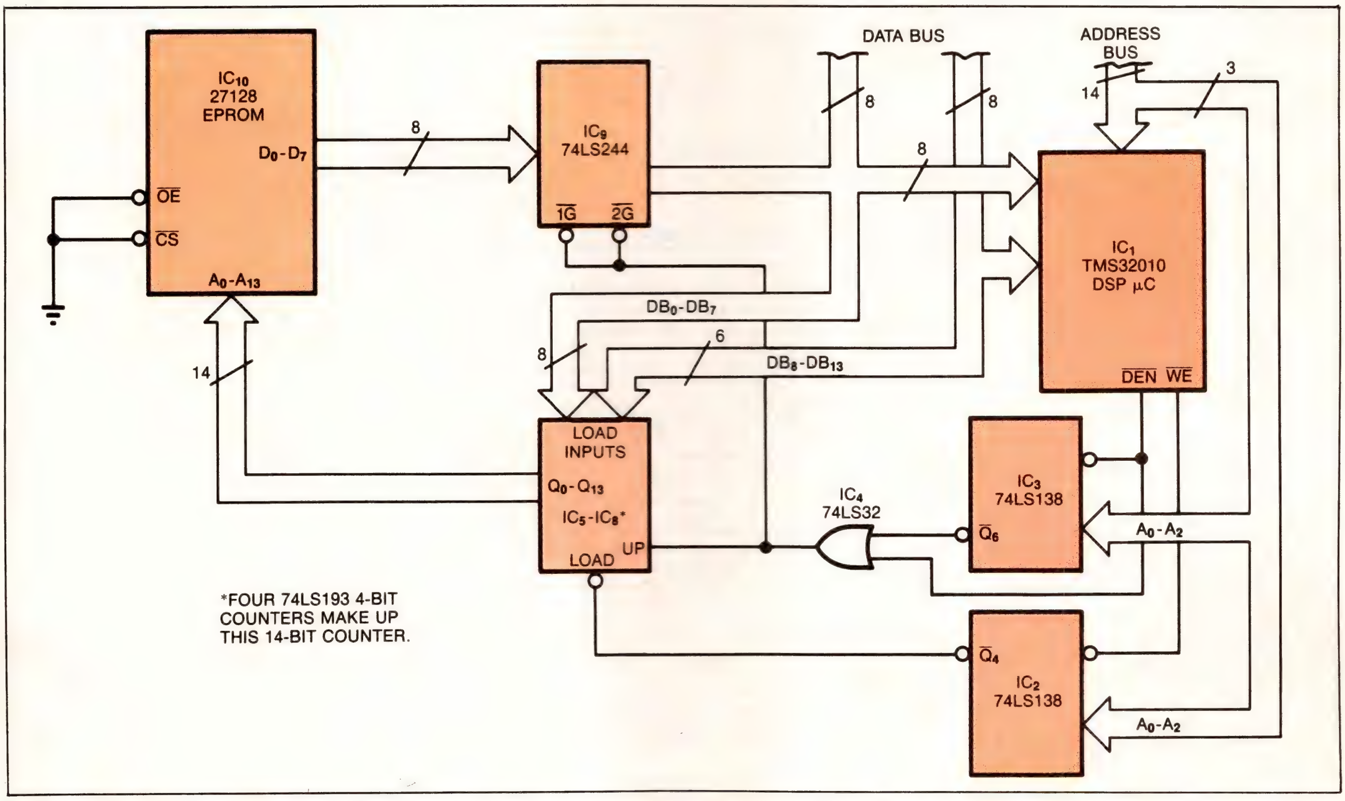

Fig 1—An external EPROM (IC_{10}) enhances the TMS32010 µC's memory space by adding 16k bytes.

Detector measures acoustic-wave speed

Gregg A Butler
Analog Devices, Wilmington, MA

You can measure the speed of sound in air and various other media by using a system that includes a balanced modulator/demodulator operating as a phase-sensitive detector **(Fig 1)**. The signal source E_{IN} provides a sinusoidal input to the phase detector IC_2 and to the piezoelectric transducer Y_1. You mount an electret microphone within the sample chamber at a known distance D from the transducer; D should exceed ¼ of the wavelength for the lowest excitation frequency used. To avoid standing-wave interference, you should place a sound-absorbing material such as cotton or fiberglass at each end of the chamber.

Op amp IC_1 amplifies the microphone signal and applies it to the phase detector, whose filtered output E_{OUT} is proportional to the delay that occurred when the signal propagated through the chamber as sound. This delay is a function of D, of the signal frequency, and of the desired propagation velocity, as well as of temperature and (to a slight degree) pressure. For a given temperature, however, you can calibrate the velocity measurement by adjusting the frequency.

When E_{IN} and the amplified microphone signal are in quadrature (that is, when their phase difference is 90°), the dc component of IC_2's output is zero, and thus the filtered output E_{OUT} is zero. You obtain this null condition by adjusting the frequency of E_{IN} (f_1). Then, you increase the frequency until a second null appears (f_2). These frequencies correspond to a phase difference ($\theta_2 - \theta_1$) of π rad:

$$\theta_2 - \theta_1 = \pi = \frac{2\pi Df_2}{V} - \frac{2\pi Df_1}{V}$$

where V is the desired sound velocity:

$$V = 2D(f_2 - f_1).$$

The circuit's frequency response is 3 to 8 kHz when using the transducer and microphone shown. (The AD630, incidentally, can process a subsonic- to 10-kHz frequency range.) When D is 6.8 in., the setup shown yields a null condition at 4 kHz and another at 5.005 kHz, resulting in a measurement of 1132 ft/sec for sound in 68°C air. **EDN**

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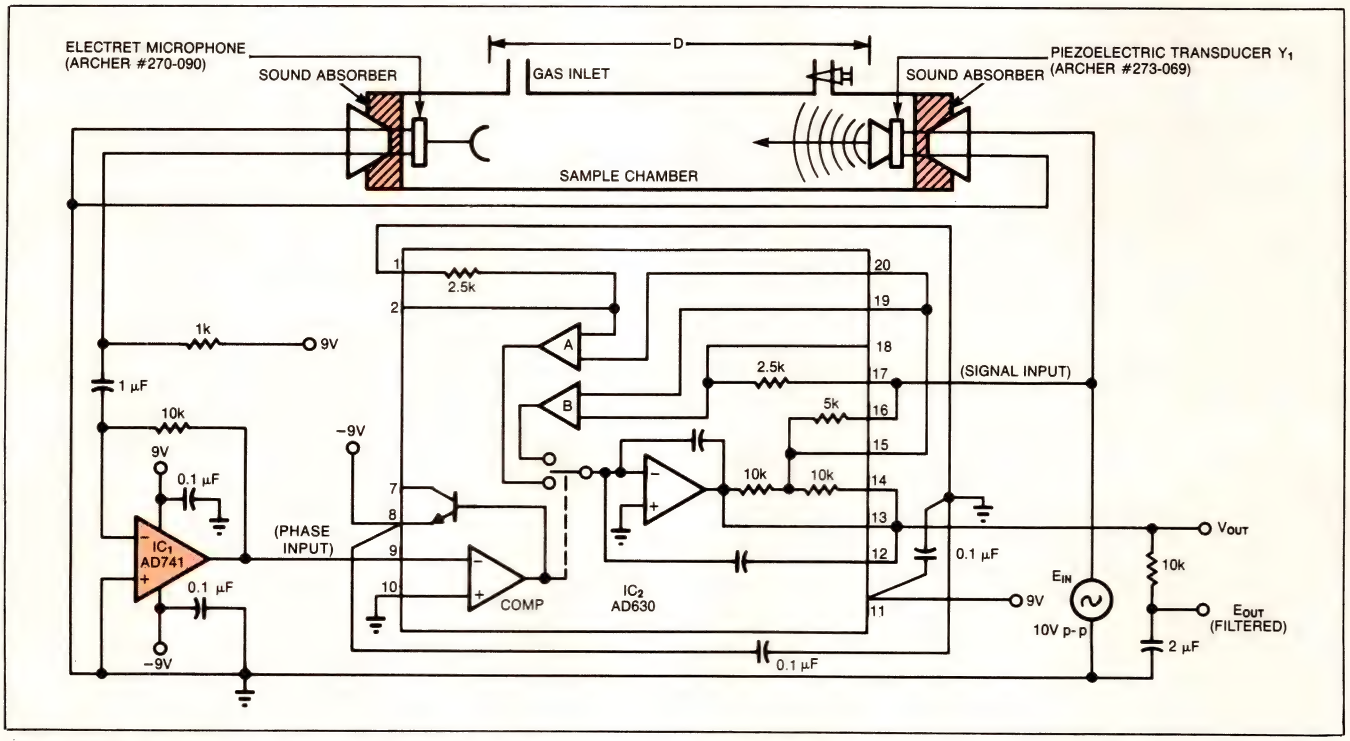

***Fig 1—This circuit measures the velocity of sound** in air (or in any medium you place in the sample chamber).*

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TFM-4	5-1250	7.5	30	21.95	(5-49)
TFM-5	5-1500	8.0	30	23.95	(5-49)
••• TFM-11	1-2000	7.5	25	39.95	(1-24)
••• TFM-12	800-1250	6.0	35	39.95	(1-24)
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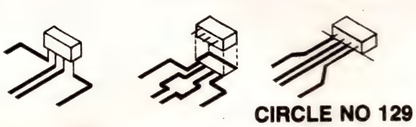

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CIRCLE NO 129

C 114 REV. ORIG.

JFET controls latched DAC during turn-on

Mike Jachowski
Precision Monolithics Inc, Santa Clara, CA

When you apply power to a system that contains latched D/A converters, the random data stored in the latches can cause momentary disruptions in the system. Until the CPU can reset and take control, the D/A converters can assert undesired outputs for 100 msec or more. You can avoid this problem by using the µP's power-up reset signal to clear some types of external latches, but you need a different scheme for converters with internal latches.

One such scheme **(Fig 1)** defines the output during power-up for the 12-bit, internally latched D/A converter IC_4. The RS flip-flop IC_5 is set during power-up ($\overline{Q}$ is low), which turns on transistor Q_1. Because Q_1 is saturated, its collector voltage is near 0V and therefore the channel resistance of the depletion-mode JFET Q_2 is below 10Ω. The FET's low on-resistance shorts out the D/A converter's internal feedback resistor, which reduces the inverting gain of V_{OUT} to near zero. (With −10V applied to the reference, the worst case output at power-up is only 14 mV, that is, 6 LSBs). This condition will remain until the CPU writes a command to the D/A converter.

$\overline{DS}$ and RD/$\overline{WR}$ go low during a write cycle to the D/A converter, resetting the RS flip-flop. The resulting high-level $\overline{Q}$ turns off Q_1, which pulls Q_2's gate to −15V, turning off Q_2. This action restores normal operation to V_{OUT} by removing the short from the D/A converter's feedback resistor. Although the JFET adds about 15 pF to the feedback loop, you can maintain settling time by simply reducing the feedback capacitor C_1 to about 18 pF. The JFET's drain-source leakage current contributes less than 0.1 LSB for a 0 to 10V V_{OUT} range.

You can use a similar technique to null the output of a D/A converter configured for bipolar output **(Fig 2)**. In this case, you place the JFET in the feedback path of

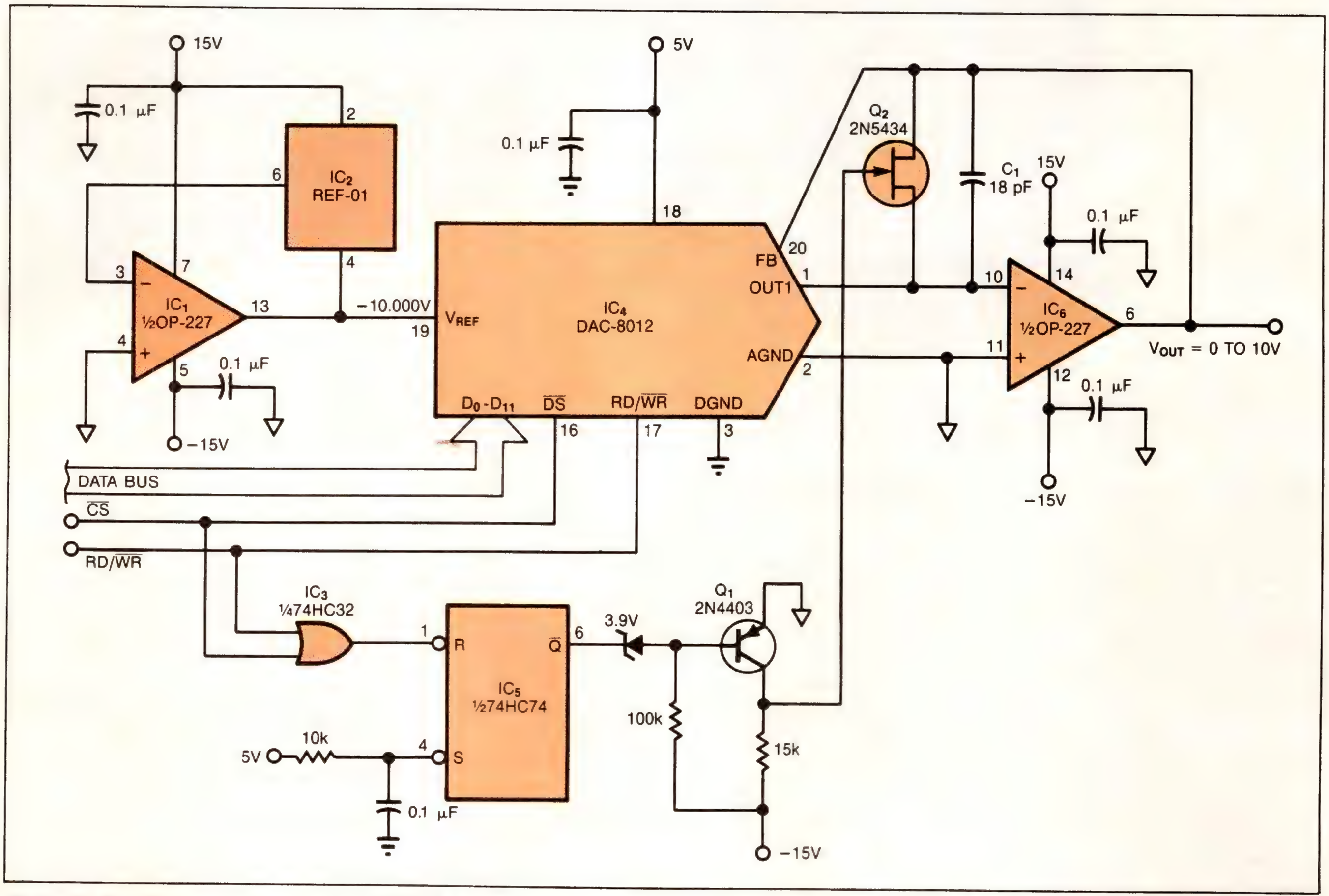

*Fig 1—**In this D/A-converter circuit,** JFET Q_2 is on during power-up, which shorts out the converter's feedback resistor and holds V_{OUT} near 0V.*

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External Memory	up to 128K of RAM or ROM	up to 64K of RAM or ROM	up to 64K of RAM or ROM
DMA	Single-channel with 16-bit pointer and count register	None	None
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Counter/Timers	3 16-bit: 2 up/down-count with bivalue and capture modes, 1 down count only	2 16-bit up-count only with 4 high-speed input units	3 16-bit up-count only
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CIRCLE NO 130

the second op amp, IC_6. Again, the JFET's low on-resistance holds the op-amp output near 0V until the CPU begins its first write operation to the converter. The circuit then operates normally, provided Q_2's gate voltage remains beyond pinch-off (at least 4V below the lowest negative value of V_{OUT}). The −15V supply level ensures this condition. **EDN**

To Vote For This Design, Circle No 749

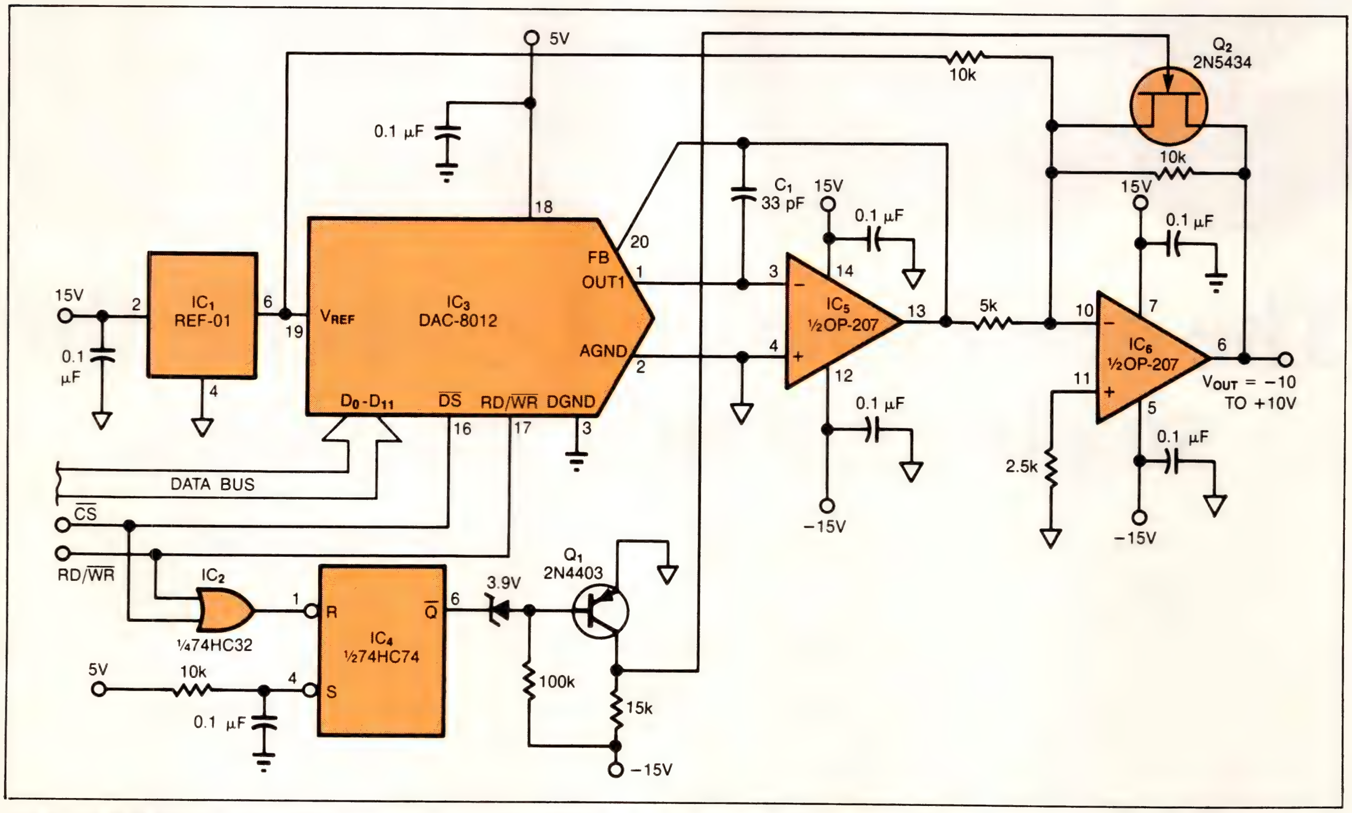

Fig 2—In this bipolar-output D/A-converter circuit, JFET Q_2 in the feedback path of op amp IC_6 performs a function similar to that of the JFET in **Fig 1.**

Circuit checks remaining battery capacity

Rolf Zinniker
Swiss Federal Institute of Technology,
Zurich, Switzerland

The test circuit in **Fig 1** gives an indication of the capacity remaining in a battery. By noting the time (in seconds) that the LED remains on after you depress the test switch S_1, you can read the remaining battery life (in hours) from the curve in **Fig 2a.** The circuit has proven reliable in testing NiCd-, carbon-, and alkaline-type batteries, all of which have a discharge-vs-time characteristic similar to the NiCd curve shown in **Fig 2b.**

Closing S_1 activates the circuit by applying voltage from the battery under test. Voltage V_1 jumps to a value $V_0=V_R R_3/(R_2+R_3)$ when the switch closes **(Fig 3)** and then increases with a time constant $T=C_1(R_2+R_3)$. The divider R_4/R_5 fixes V_2. The reference circuit IC_1 sets V_R to approximately 2.5V.

The op amp's output remains high (LED on) until V_1 rises to the level of V_2, when the LED turns off. You calculate the on-time t_{ON} as follows:

$$t_{ON} = T \cdot \ln\left(\frac{V_R - V_0}{V_R - V_2}\right).$$

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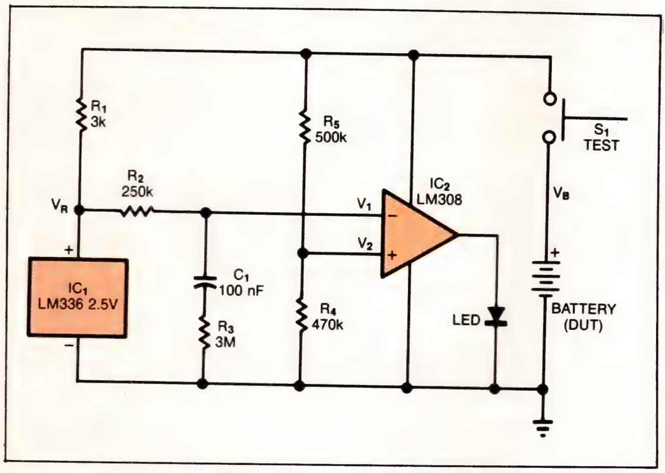

Fig 1—This test circuit checks the remaining charge *in a battery; the charge is proportional to the time the LED remains on after you depress S_1.*

The on-time is zero when $V_2 < V_0$ and infinite when $V_2 > V_R$. By substituting t_{ON} for t and V_2 for V_1 in **Fig 3,** you obtain a curve for t_{ON} as a function of V_2.

You must choose voltages V_S and V_E **(Fig 2b)** that correspond to the desired range for t_{ON}. Then, set the resistor values as follows:

$$\frac{R_4}{R_5} = \frac{V_R}{V_S - V_R}; \quad \frac{R_3}{R_2} = \frac{V_E}{V_S - V_E}.$$

You can make R_5 a variable resistor for convenience in calibrating the circuit. Because the curves of **Fig 2b** and **Fig 3** have a similar rate of change over the range of interest, the resulting relation **(Fig 2a)** between t_{ON} and remaining battery lifetime is quite linear. To use the circuit, simply depress S_1 and hold it. If the LED remains on for several seconds, the battery contains more than 70% of its rated charge. If the LED remains on for only 0.5 sec, for example, the battery is good for approximately four hours while loaded as in **Fig 2b,** that is, with 100Ω. **EDN**

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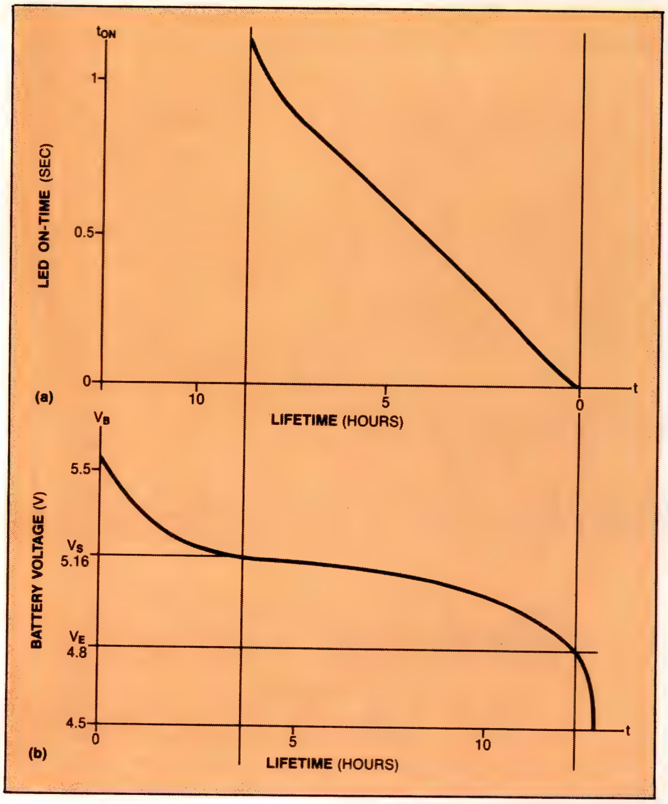


Fig 2—The calculated on-time *in seconds for the LED in* ***Fig 1*** *corresponds to the battery's remaining life in hours, based on a 100Ω load* ***(a).*** *The curve in* ***b*** *shows the measured rate of discharge for a NiCd battery (four Varta RS600 cells loaded with 100Ω).*

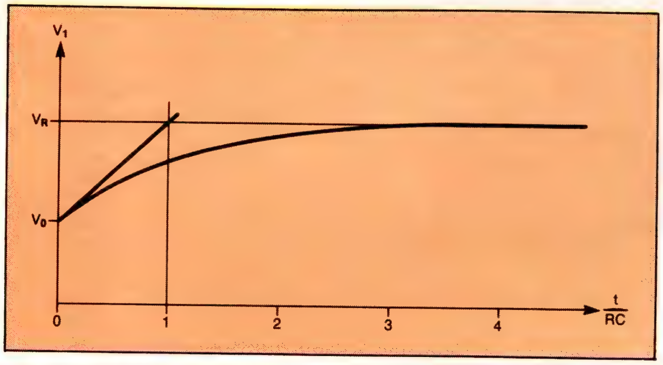
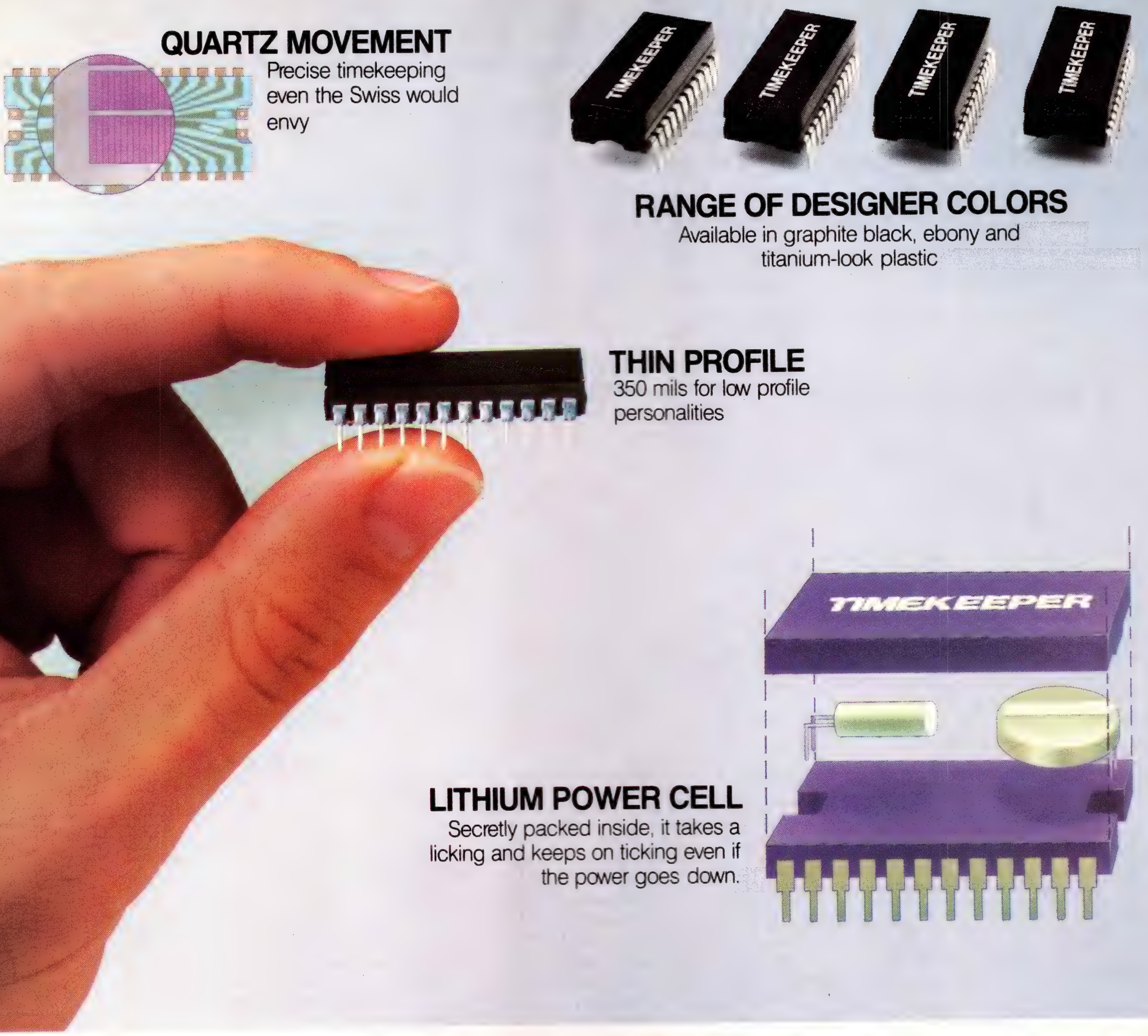


Fig 3—This curve shows the variation of *V_1 following closure of S_1 and caused by the charging of capacitor C_1.*

Circuit counts pulses for μP system

Ricardo Jiménez
Mexicali Technological Institute, Calexico, CA

The circuit of **Fig 1** measures the period of the input signal and displays on an LCD the corresponding pulse rate in pulses/minute. The circuit is useful for monitoring the 0.46- to 6-sec periods found in biomedical systems (for example, 0.46 sec corresponds to an upper limit for heartbeat rates—130 beats/minute, and 6 sec corresponds to a lower limit for respiratory rates—10



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breaths/minute).

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Nine bits of the counter's 12-bit binary output are sufficient to handle the expected range of inputs. The 9-bit output addresses EPROMs IC$_5$ and IC$_6$ in parallel. Each selected memory location contains an appropriate BCD code as shown in **Listings 1** and **2** (data and addresses are in hexadecimal code). Next, the BCD-to-

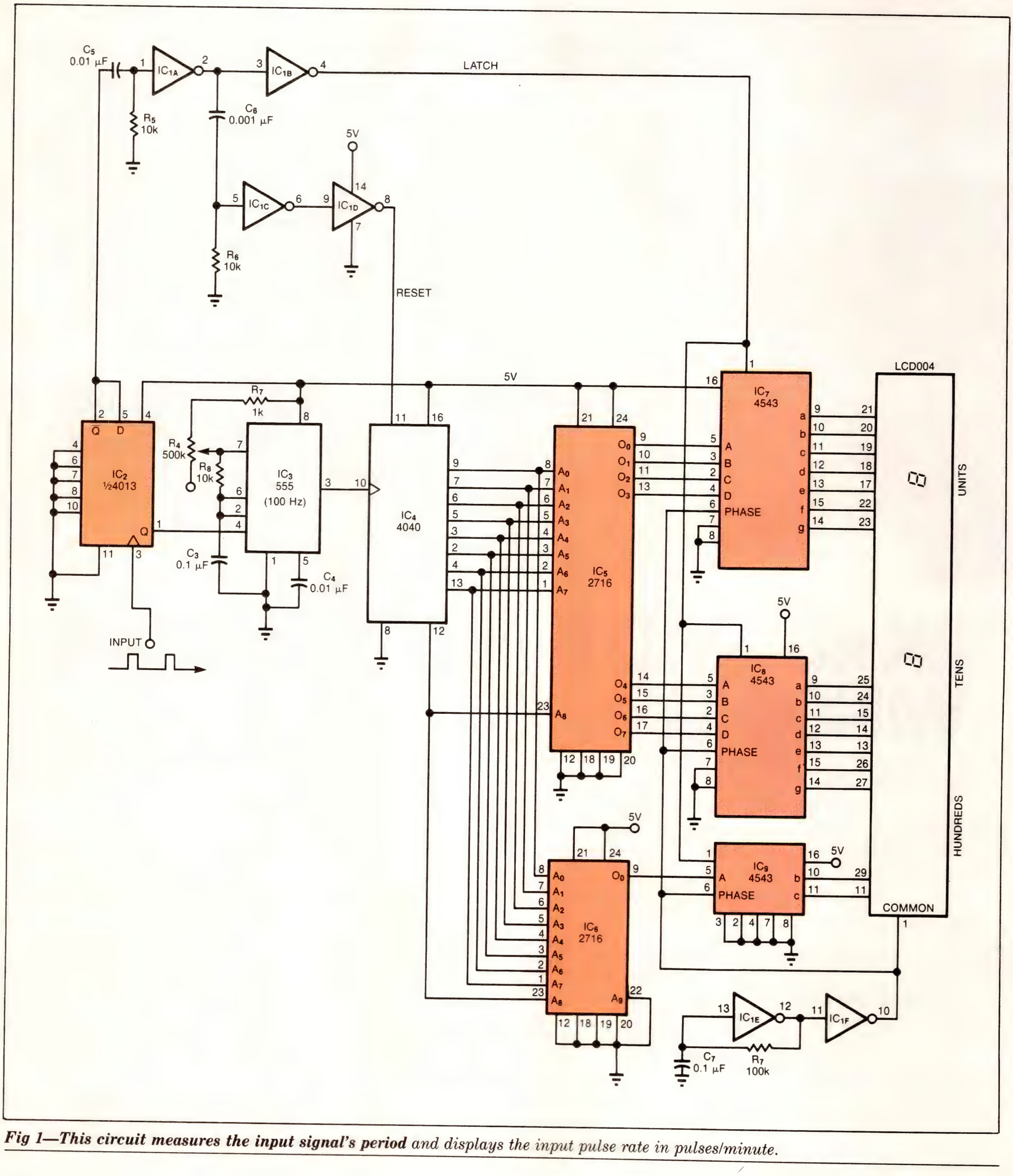

*Fig 1—**This circuit measures the input signal's period** and displays the input pulse rate in pulses/minute.*

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EPROM IC$_6$ acts as a 9-bit comparator. Its output is high for inputs corresponding to a display of 100 and up; otherwise, its output is low. **EDN**

To Vote For This Design, Circle No 748

LISTING 2—PROGRAM FOR IC$_6$

ADDRESS	DATA
2E	1
2F	1
30	1
31	1
32	1
33	1
34	1
35	1
36	1
37	1
38	1
39	1
3A	1
3B	1
3C	1

LISTING 1—PROGRAM FOR IC$_5$

ADDRESS	DATA
2E	30
2F	28
30	24
31	22
32	20
33	18
34	16
35	14
36	12
37	10
38	08
39	06
3A	04
3B	02
3C	00
3D	98
3E	96
3F	95
40	94
41	92
42	91
43	90
44	88
45	87
46	86
47	84
48	83
49	82
4A	81
4B	80
4C	79
4D	78
4E	77
4F	76
50	75
51	74
52	73
53	72
54	72
55	71
56	70
57	69
58	68
59	68
5A	67
5B	66
5C	65
5D	65
5E	64
5F	63
60	63
61	62
62	61
63	61
64	60
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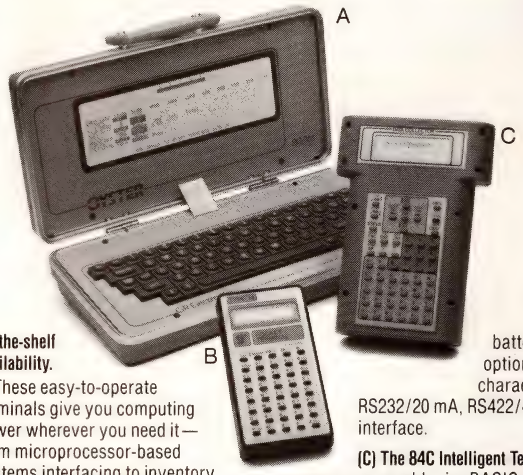

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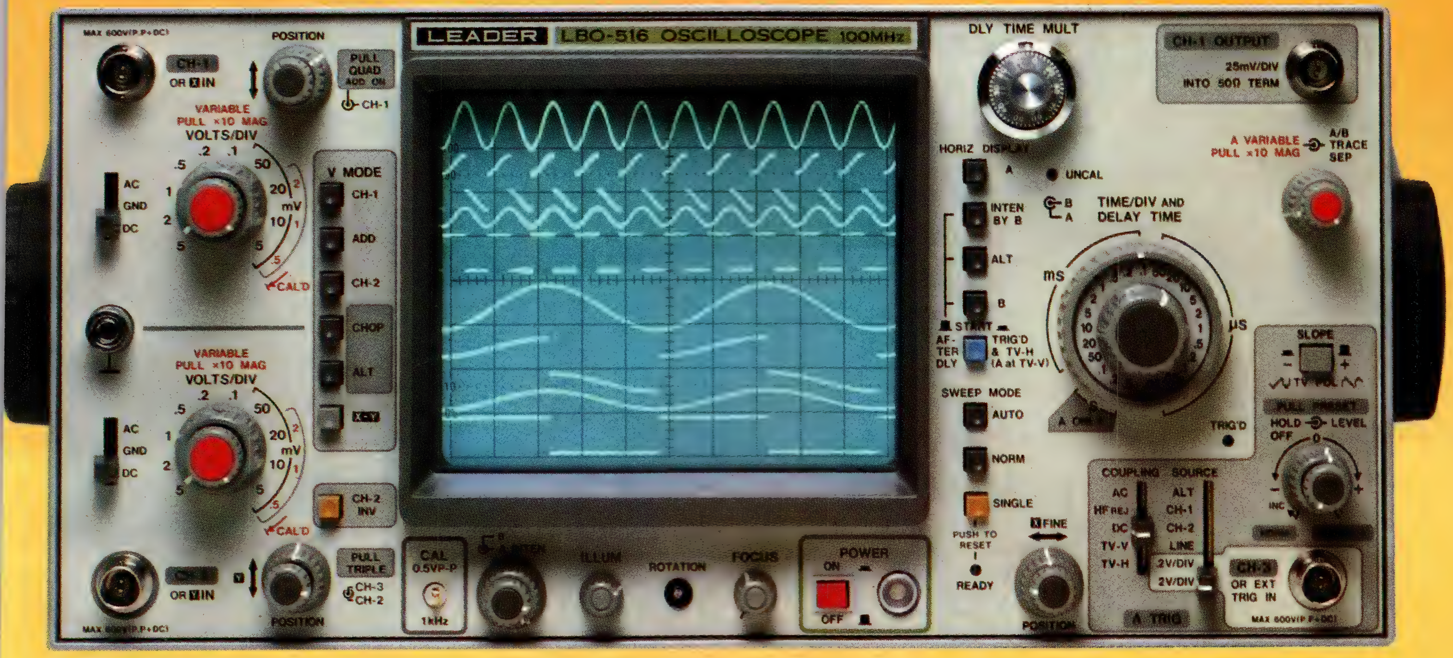

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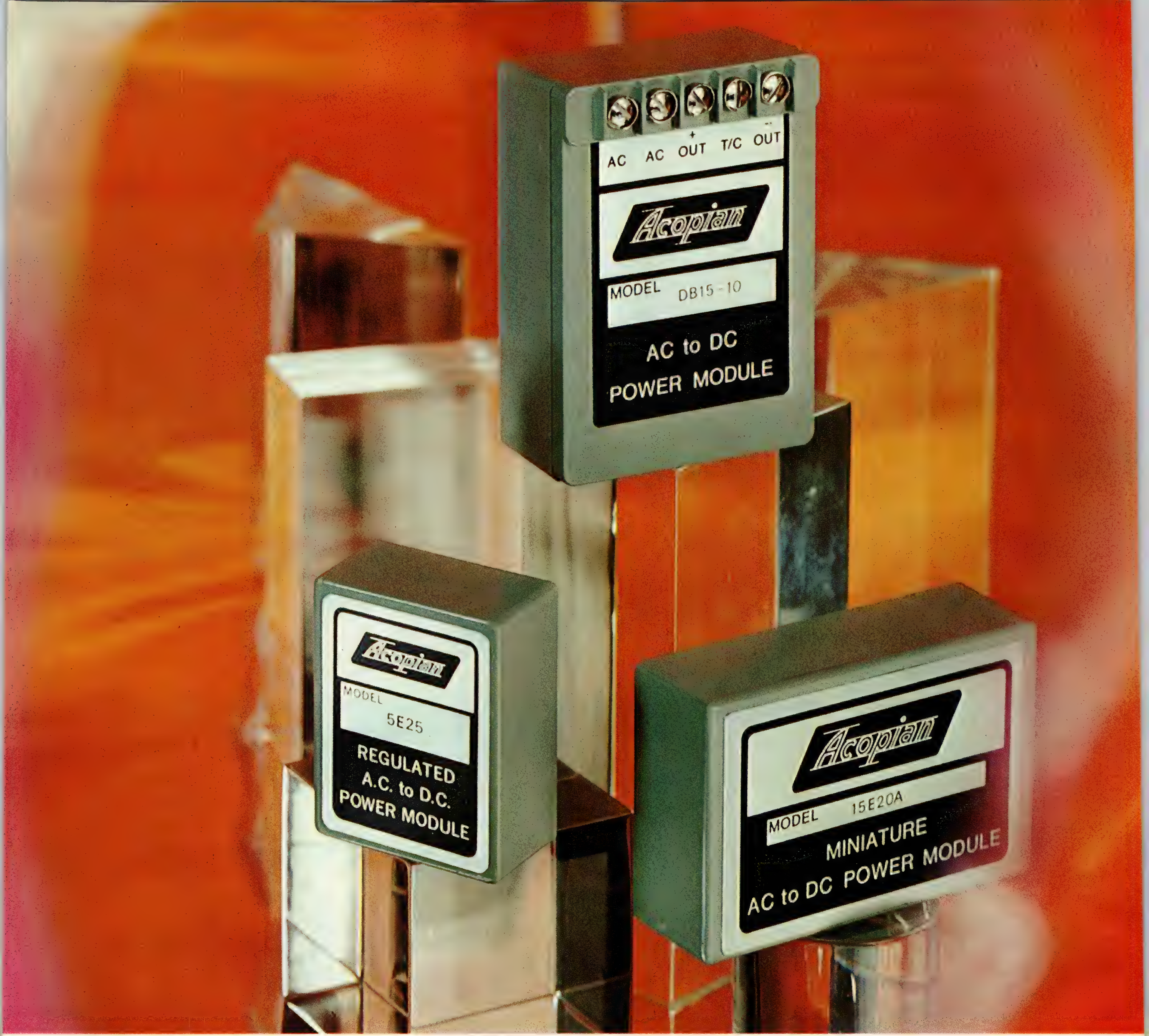

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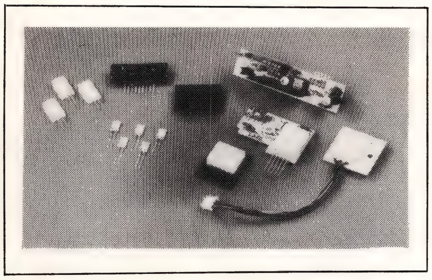


HUMIDITY SENSOR

- *Design minimizes degradation of accuracy*
- *Current and voltage outputs available*

The RH-8 sensor and the SCMC signal-conditioning microcircuits are for constructing humidity transmitters. The RH-8 is a bulk-resistance-polymer relative-humidity (RH) sensor. The bulk-polymer design minimizes accuracy degradation due to contamination and keeps long-term drift below 1% per year. Onboard temperature compensation provides accurate humidity outputs from 0 to 50°C over a humidity range of 0 to 95%. The SCMC-V provides a linearized 0 to 1V dc output, and the SCMC-I provides a linearized, 2-wire, 4- to 20-mA output. In a simple circuit, the combination of the RH-8 and an SCMC will produce an accuracy of ±3% RH. RH-8, less than $20; SCMC-V, $15; SCMC-I, $18 (200).

General Eastern Instruments Corp, 50 Hunt St, Watertown, MA 02172. Phone (800) 225-3208; in MA, (617) 923-2386.

Circle No 351

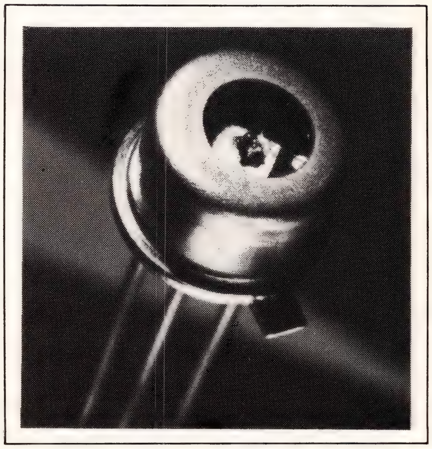
OPTICAL SOURCES

- *Built-in lens increases coupling efficiency*
- *Minimum launch power guaranteed*

The MFOE1100 Series of LEDs uses an AlGaAs process to enhance output power, and a built-in lens to increase coupling efficiency. The package fits directly into standard fiber-optic connector systems. The output wavelength equals 805 nm typ. The minimum launch power (at I_F=100 mA for a 100-µm-core fiber) is guaranteed at 60 µW for the MFOE1100, 120 µW for the MFOE1101, and 180 µW for the MFOE1102. The emitters are compatible with the company's line of fiber-optic detectors. MFOE1100, $11.25; MFOE1101, $15.96; MFOE1102, $20.63 (100). Delivery, stock to six weeks ARO.

Motorola Semiconductor Products Inc, Box 52073, Phoenix, AZ 85036. Phone (602) 244-3818.

Circle No 352



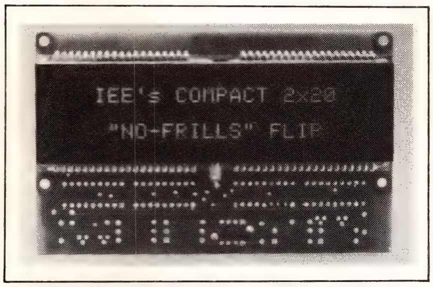
CONNECTOR

- *10,000-cycle minimum lifetime*
- *ZIF design*

A rack-and-panel connector, the DL Drawer features zero-insertion-force assembly to extend contact life and protect against mismating. It uses the axial thrust of a cam to move the contacts into high-force electrical contact. The connector's lifetime is 10,000 mate/unmate cycles minimum. The connector features layouts of 60 to 156 contacts configured on a 0.1-in. grid. Contacts come in strips and on reels for efficient crimping by crimp machines or stripper-crimper devices. Custom layouts with higher contact counts are also available. $0.60 to $0.75 (OEM qty). Delivery, 12 to 16 weeks ARO.

ITT Cannon, Box 8040, Fountain Valley, CA 92728. Phone (714) 964-7400.

Circle No 353



DISPLAY MODULE

- *Offers the full 96-character ASCII set*
- *Two lines of twenty 5×7 dot-matrix characters*

The 3601-85-040 vacuum-fluorescent display module features two lines of twenty 0.2-in.-high, 5×7 dot-matrix characters. An onboard μP controller handles all scan, refresh, and data-I/O tasks, easing the task of interfacing to an 8-bit ASCII parallel data bus. The module requires 5V dc for operation. It displays the 96-character ASCII set of upper- and lower-case letters, numbers, and symbols. Display characters are blue green, but a spectrum of color filters is available. $91 (100).

IEE Inc, 7740 Lemona Ave, Van Nuys, CA 91409. Phone (818) 787-0311.

Circle No 354

DISPLAY

- *Accepts 4-bit parallel data*
- *Electroluminescent backlighting available*

Series F642F displays are 640×400-dot LCD modules. Measuring 10.6×7.8×0.5 in., each module has a dot pitch of 0.014×0.014 in., a dot size of 0.013×0.013 in., and dot spacing of 0.001 in. The active area of the display measures 9×5.6 in., and the viewing area is 9.3×6 in. The module accepts 4-bit parallel data and has CMOS drivers on an integral circuit board. Except for a character generator, the module incorporates all the necessary LCD drive circuitry. $343.80 (100). Delivery, eight weeks ARO.

Seiko Instruments USA Inc, 2290 W Lomita Blvd, Torrance, CA 90505. Phone (213) 530-8777.

Circle No 355

DUAL SUPPLIES

- *Operate from either 115 or 230V ac*
- *Regulation equals ±0.02%*

Models 2.12.240 and 2.15.200 are modular, dual-output power supplies that offer outputs of ±12V dc at 240 mA and ±15V dc at 200 mA, respectively. Both units operate

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If your design includes an 80C31 system, EDI's all CMOS μPak provides a space-saving
pin to pin compatible to the 80C31, the μPak is a low power, space-saving powerhouse.
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Electronic Designs Inc., 42 South Street, Hopkinton, MA 01748, USA, Telephone (617) 435-2341, TELEX 948004
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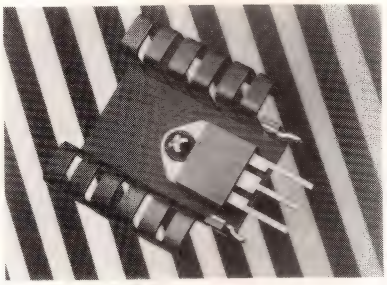
from either 115 or 230V ac, selectable via jumpers or an external switch. The dual-input capability allows you to use equipment designed for the domestic market overseas with no modifications, because the 230V input can handle most European voltages. Specifications include regulation of ±0.02% and output noise of 1 mV rms. $104.

Calex Mfg Co Inc, 3355 Vincent Rd, Pleasant Hill, CA 94523. Phone (415) 932-3911.

Circle No 356

HEAT SINK

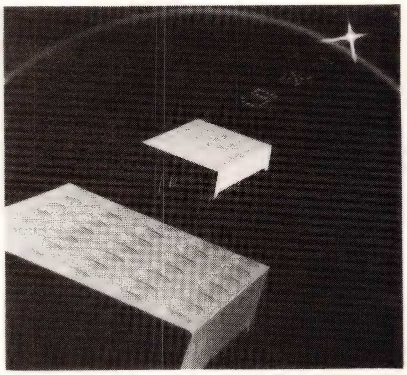
- *Designed for TO-218 and TO-220 packages*
- *Dissipates as much as 10W*



The 5931 heat sink is made using stamp technology but provides the thermal performance of the more expensive extruded devices, according to the company. Designed for TO-218 and TO-220 packages, it mounts in a vertical position and accommodates semiconductor devices on both sides. Under natural convection, the heat sink dissipates 10W max. The 1.64-in.-high heat sink has two solderable tabs for mounting. Made of aluminum alloy, the heat sinks are available in gold chromate and black, red, blue, and bronze anodized finishes. $0.219 (1000).

Aavid Engineering Inc, Box 400, Laconia, NH 03247. Phone (603) 524-4443.

Circle No 357



LEDs

- *Available in 1.04- and 0.68-in. character heights*
- *Viewing distances range to 18m and 12m*

These red, 5×7 dot-matrix alphanumeric LED displays, the HDSP-470X and HDSP-440X, have character heights of 0.68- and 1.04-in., respectively. Viewing ranges are 18m for the 470X and 12m for the 440X. Housed in DIPs, both dis-

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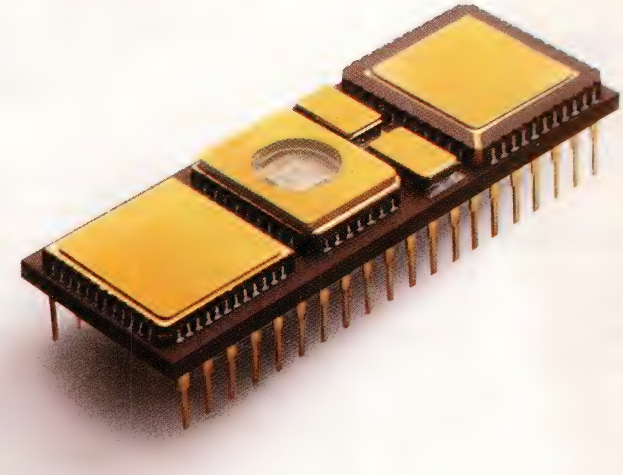
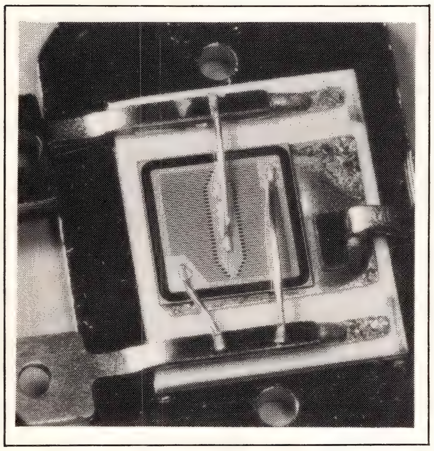


CIRCLE NO 138

plays are available in either common-row anode or common-row cathode versions. You can stack the modules to create an X-Y grid. They're suitable for graphics-panel applications because they are categorized according to luminous intensity, so you can choose modules that ensure a uniform appearance. HDSP-4400 Series, $7.18; HDSP-4700 Series, $6.65 (101).

Hewlett-Packard Co, 1820 Embarcadero Rd, Palo Alto, CA 94303. Phone local office.

Circle No 358



GTO THYRISTORS

- *Handle average on-state currents as high as 25A*
- *Feature on-chip protection diode*

The BTV60D Series 15A gate turn-off thyristors feature an on-chip antiparallel protection diode, which has a reverse recovery time of 600 nsec. The thyristors are for use in high-frequency inverters, power supplies, and PWM ac motor drives. They can carry an average on-state current as high as 25A, and they have a nonrepetitive peak on-state current rating of 240A. They can switch off a 120A anode current in less than 300 nsec. The thyristors are available with repetitive peak off-state voltage ratings of 850, 1000, and 1200V, and they are housed in a TO-238AA package. Approximately $20 (1000). Delivery, 12 weeks ARO.

Philips, Elcoma Div, Box 523, 5600 AM Eindhoven, The Netherlands. Phone (040) 757005. TLX 51573.

Circle No 359

Amperex Electronic Corp, George Washington Hwy, Smithfield, RI 02917. Phone (401) 232-0500.

Circle No 360

EMI FILTERS

- *Insertion loss specified to 18 GHz max*
- *Have no high-Q resonances*

To prevent microwave modules' dc inputs from carrying EMI, the DLT4/L/22000/S miniature chassis-mounting EMI-suppression filters have a minimum insertion loss at 25°C of 65 dB over the 1- to 18-GHz range. The filters are 100% tested using a sweep-frequency-measurement technique to ensure that they have no high-Q resonances over this frequency range. To achieve this performance, the filters incorporate the company's Ceramox multilayer discoidal capacitors; the filters also have palladium electrodes to provide long-term reliability. The devices come with a threaded stud for chassis mounting. £3.50 (1000).

Oxley Developments Co Ltd, Priory Park, Ulverston, Cumbria LA12 9QG, UK. Phone (0229) 52621. TLX 65141.

Circle No 361

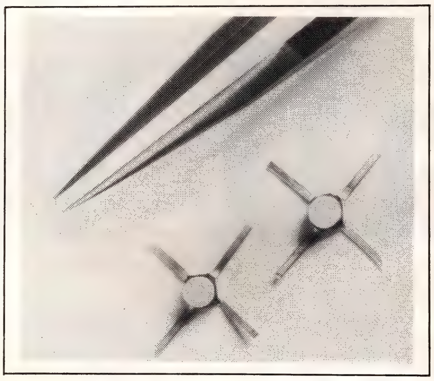
PORT ADAPTER

- *Transparent to a computer and printer*
- *Features an internal data buffer for storage*

This parallel-to-serial port converter, the Converser, converts the parallel port of an IBM PC or compatible system to a serial port, allowing you to drive a serial printer. Featuring an internal data buffer that stores the computer's output, the device connects directly to a parallel-printer cable and eliminates the need for serial-interface cards. Transparent to a computer and printer, the converter supports the most common serial protocols (X-On/X-Off, DTR), making it suitable for use with PCs and DEC printers. Two models are available: the PS-16, equipped with 16k bytes of buffer memory, and the PS-64, equipped with 64k bytes. PS-16, $149; PS-64, $229.

Gold Key Electronics Inc, Box 186, Goffstown, NH 03045. Phone (800) 325-0150; in NH, (603) 625-8218.

Circle No 362



GaAs FETs

- *Offer noise figures from 0.5 to 1.2 dB*
- *Operate over the 2 to 12 GHz range*

The ATF-10135, -10235, and -20135 FETs come in microstrip ceramic packages. Suited for general-purpose and oscillator applications at 4 GHz, these 0.5-μm gate-length GaAs FETs are all usable over the 2- to 12-GHz range. Noise figures range from 0.5 to 1.2 dB; associated gains run from 12.5 to 12.8 dB, and power outputs (at 1-dB compression) equal 18 to 19 dBm. ATF-

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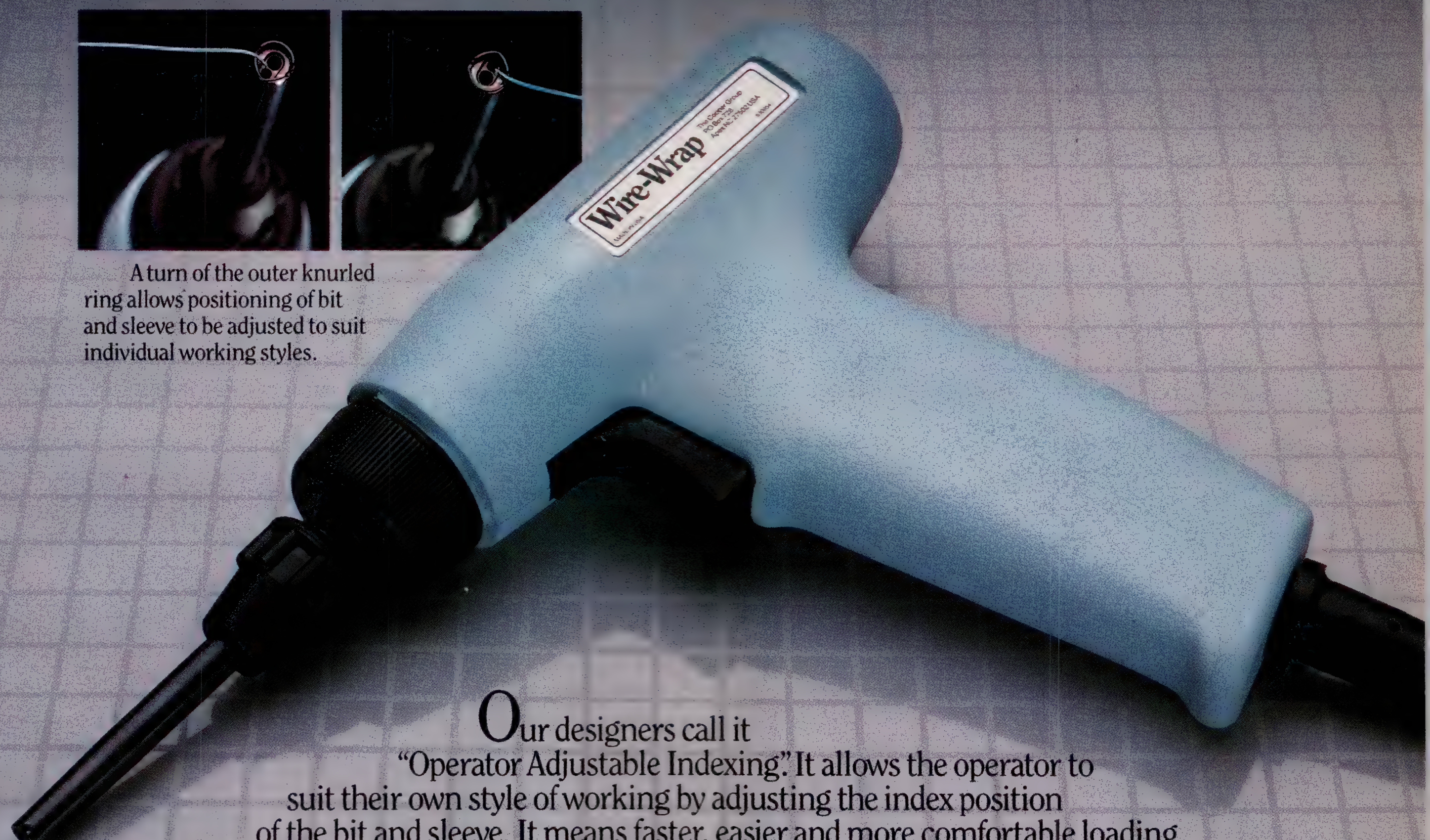

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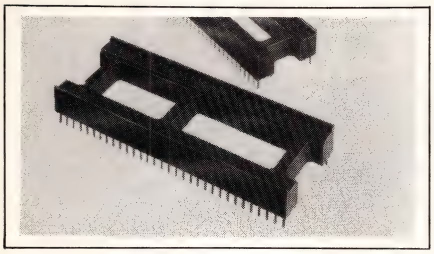
Avantek Inc, 3175 Bowers Ave, Santa Clara, CA 95054. Phone (408) 970-2583.

Circle No 363



SOCKETS

- *Single-beam contact pins have low insertion force*
- *Housing has 94V-0 UL rating*

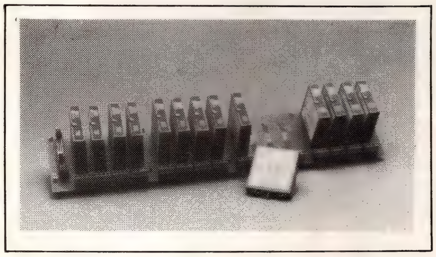
The Series 570 stamped pin sockets are designed for shrink-pack ICs that have a 0.07-in. pin-to-pin spacing. They feature single-beam contact pins that have a low insertion force. The glass-filled polyester housing has a 94V-0 UL rating and features guide rails to ease the insertion process. The contact pins are tin-plated beryllium copper. Units having 40 and 52 positions with pins on 0.6-in. centers are available, as are 64-position sockets with center spacings of 0.75 in. $1.46 (1000) for 64-pin socket.

Aries Electronics Inc, Box 130, Frenchtown, NJ 08825. Phone (201) 996-6841.

Circle No 364

SIGNAL CONDITIONERS

- *Laser-trimmed for high accuracy*
- *For electrically noisy environments*



The input modules in the 5B Series of signal conditioners accept signals from thermocouples and RTDs as well as millivolt, volt, and 4- to 20-mA signals; the output module provides a 0- to 20-mA or 4- to 20-mA signal. The modules are laser-trimmed to produce a ±0.05% accuracy. They have no potentiometers and are completely sealed. The modules are designed for electrically noisy environments. They provide ±1500V isolation, 160-dB common-mode rejection, 60-dB normal-mode rejection, and 240V input protection, and they meet IEEE-STD-472 to withstand 2500V transients. Chopper-based amplification ensures ±0.0025%/°C max drift, and typical nonlinearity equals ±0.01%. All units provide linearization when required. They

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CIRCLE NO 140

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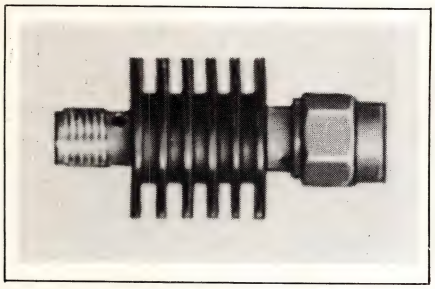
operate from 5V over a −25 to +85°C range. $105 (100).

Analog Devices Inc, 70 Shawmut Rd, Canton, MA 02021. Phone (800) 245-3900; in MA, (617) 461-3643.

Circle No 365



ATTENUATORS

- *Perform with an accuracy of 0.3 to 0.5 dB*
- *10W version spans dc to 18 GHz*

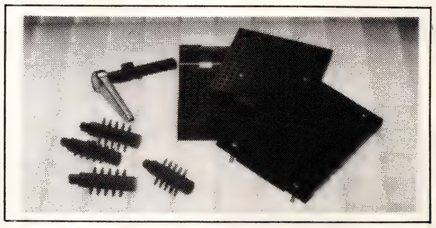
The 50 MHP Series of attenuators includes a 10W average power model with a frequency range of dc to 18 GHz, and attenuations of 1 to 10 dB. A 5W model offers 1- to 20-dB attenuations. These fixed attenuators have a VSWR of 1.35:1 max. Attenuation accuracy specs at 0.3 dB from 1 to 7 dB and 0.5 dB from 8 to 20 dB. Both models are equipped with SMA connectors conforming to MIL-C-39012. The 10W model, $85; the 5W model, $65.

Alan Industries Inc, Box 1203, Columbus, IN 47202. Phone (800) 423-5190.

Circle No 366

SOCKET KIT

- *Includes all necessary assembly parts*
- *ZIF feature protects fragile pins*



The Grid ZIP PGA kits allow you to build custom sockets for unique and small-quantity pin-grid-array IC packages for testing and prototyping. The kits are available in matrix sizes from 10×10 to 21×21 pins. All necessary assembly parts are included in the kit, including a base plate, a cast-metal cam lever, and assembly screws. You can order standard gold-plated beryllium-copper contacts separately. The zero-insertion-force feature protects fragile pins from damage during insertion and withdrawal. The socket contacts lock securely into place with a cam action for positive electrical contact without side-to-side stress on the pins. Assembly instructions are included. A 10×10 kit with 20 contacts and pattern plugs, $14.95 (10).

3M, Box 2963, Austin, TX 78769. Phone (512) 834-6563.

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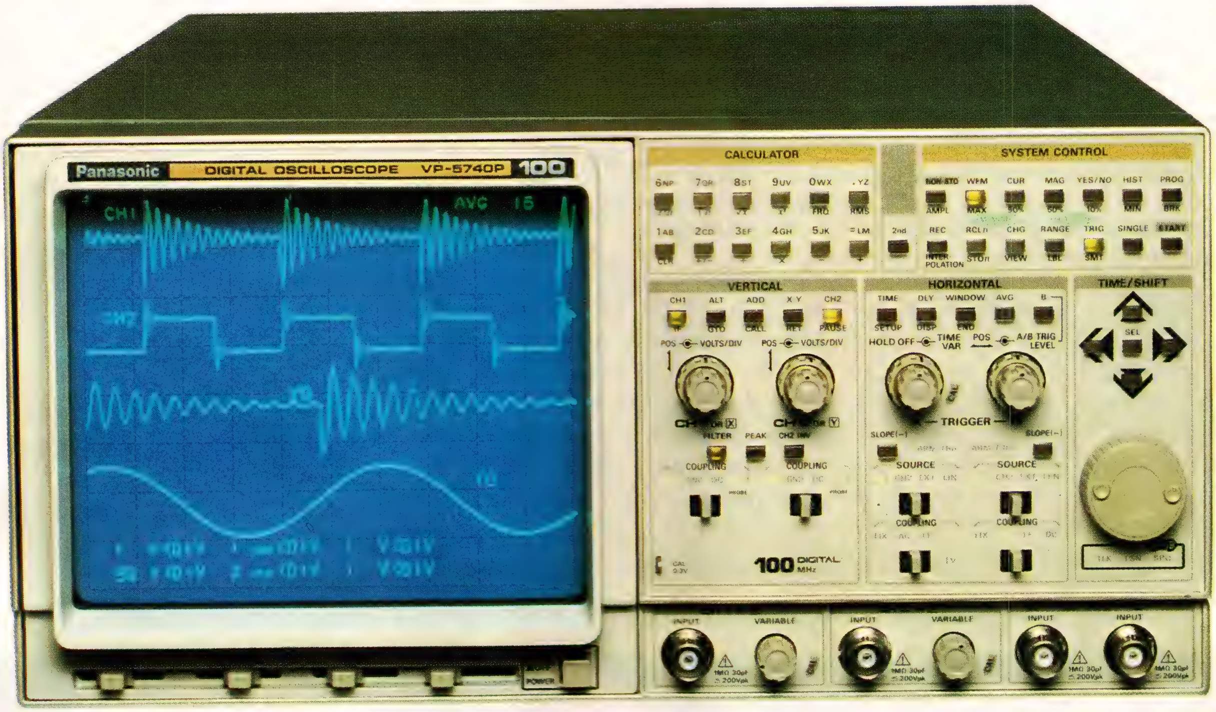
Our 100MHz Digital Oscilloscope calculates, analyzes, memorizes...and it's programmable too.



Three 10-kiloword memories, 7″ CRT display, 100MHz sampling clock and various data processing functions.

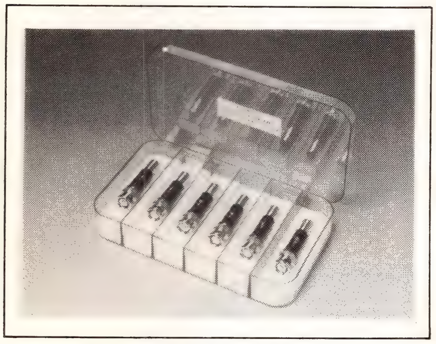
In this advanced day and age you need more than just a measuring instrument. You need a unit that thinks and remembers for you. For high-speed transient signals, meet the VP-5740P, a scope with a 100MHz sampling clock and three 10-kiloword memories.

Programming, which includes panel operation sequence and waveform/waveform-parameter calculations, gives you automatic measurements. Accumulated and memory waveforms and corresponding digital information can be viewed on a large 7″ CRT display. You also have GP-IB interfacing plus a wide variety of built-in computer functions including interpolation and YES/NO decisions. And, as a non-storage oscilloscope, the VP-574OP offers high performance with 100MHz dual trace and delayed sweep.

For more information or a free demonstration, contact your local Panasonic Instrumentation representative or: Panasonic Industrial Company, Memory Systems Division, One Panasonic Way, Secaucus, NJ 07094.
(201) 392-4050.

Panasonic
Industrial Company

- 100 Megasamples per/second digitizing
- Three 10K word memories
- 35MHz single shot
- Internal programming capabilities (up to 1000 steps)
- Math pack, algebraic and calculus functions
- Advanced cursor function
- Rise-time calculations with auto min-max feature
- Waveform expansion
- 100MHz analog 2-channel oscilloscope
- Auto-ranging
- Alphanumeric display
- µP control-front panel
- GP-IB standard
- Multiple YES/NO function
- Future memory expandability



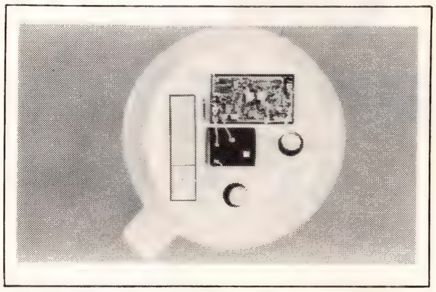
ATTENUATOR KIT

- *All attenuators are fully shielded*
- *Individual attenuators available for replacement needs*

The RFA-4057-1 attenuator kit includes six 1W BNC in-line attenuators in values of 1, 2, 3, 6, 10, and 20 dB. All units are fully shielded and then molded in a color-coded plastic sheath to indicate the value. The attenuators operate to 1.5 GHz and have an accuracy of ±0.2 to ±0.6 dB. All BNC fittings have gold pins and are silver plated. The attenuators come in a sturdy storage case. Individual units are available for replacement purposes. $69.95.

RF Industries, 690 W 28th St, Hialeah, FL 33010. Phone (800) 233-1728; in FL, (305) 888-1676.

Circle No 368



OPTICAL MODULES

- *Eliminate need for external peripheral circuitry*
- *Operating range spans several kilometers*

The 10M-bit HFE4010 transmitter and the 5M-bit HFD3000 have all the necessary driver circuitry integrated into the same package and thus eliminate the need for external peripheral circuitry. The receiver has a sensitivity of less than 1 μW, allowing operation over several kilometers. It contains a photodiode, a preamplifier, gain stages, a TTL output stage, and a regulator. The transmitter includes a GaAlAs LED (with a microlens) and a TTL-compatible driver circuit. The operating range is −55 to +125°C; the parts operate from a 5V supply. Both devices are housed in TO-46 metal packages that can be mounted in a variety of receptacles or active connectors. HFE4010, $22; HFD3000, $19.47 (100).

Honeywell Optoelectronics Div, 830 E Arapaho Rd, Richardson, TX 75081. Phone (214) 234-4271.

Circle No 369

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GOOD NEWS WHEN YOUR SYSTEM DESIGN NEEDS IT MOST . . .

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We know what you want and you don't want to wait. Our 12-Bit, 1 MHz A/D converters are in stock and ready to go! The ADC1201 and the ADC5245/5246 meet all your requirements and then some.

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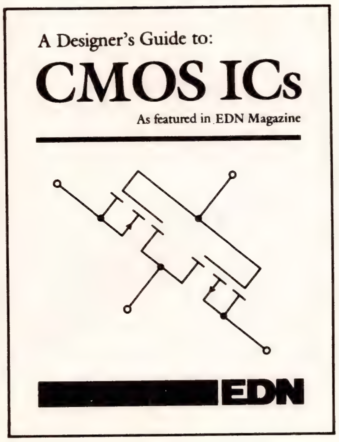

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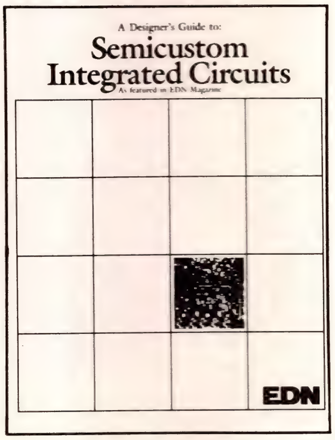
CMOS is fast becoming the chosen technology for developing integrated circuits. That's because CMOS ICs are able to implement ultra-complex system-level functions on a chip! Now you can meet the special challenges posed by this new breed of ICs with *A Designer's Guide to CMOS ICs.* You'll learn the advanced design and fabrication techniques required. Plus the latest linear and digital CMOS ICs available.



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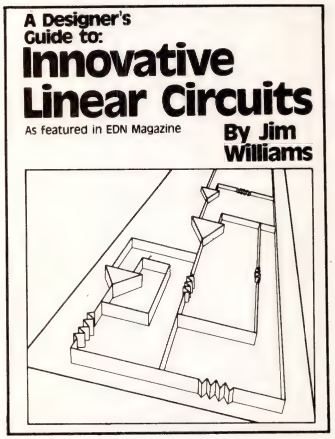
Learn how to design a semicustom IC with *A Designer's Guide to Semicustom Integrated Circuits.* Based on EDN's own design experience, this nine-chapter booklet outlines the complete procedure used to design, fabricate, and test EDN 1, a chip with a 1200 equivalent-gate complexity. You'll not only learn the steps to take when creating ICs, but also the design/cost analyses and vendor-interface methods that lead to successful semicustom chips.



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As exciting as digital technology is, you still need analog circuitry to operate on signals from real-world sources. Now, EDN is offering a wealth of analog design information in *A Designer's Guide to Innovative Linear Circuits.* This 186-page collection of articles was developed by Jim Williams, one of America's foremost linear-circuit designers. It includes practical and efficient ways to use op amps, comparators, data converters, and other analog ICs, and discusses the theories behind all the design techniques presented.

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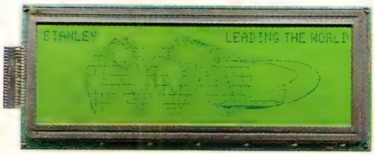
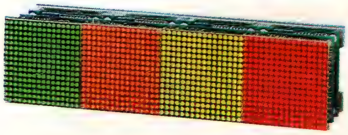


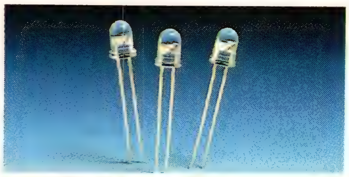
■Stanley Dot Matrix LCD Module for Graphic Displays
Compact, lightweight and thin, this clear high-contrast display packs plenty of graphic information into your handheld computer, message display equipment, or word processor.

DOT MATRIX LIQUID CRYSTAL DISPLAY MODULE
40 CHARACTERS X 2 LINES (5X7DOTS+CURSOR)

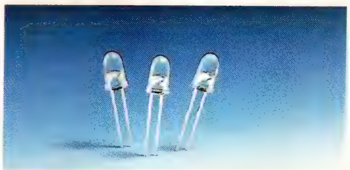
■Stanley Dot Matrix LCD Module
Full alphanumeric capacity is provided by this high-performance module with 5 × 7 dot matrix characters. All control, refresh and display functions are executed by an on-board driver.



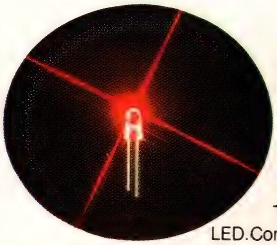
■Stanley Large-Sized LED Graphic Display Unit
For words and pictures that make a moving display that is big-as-life, these units are X-Y stackable in units of 16 × 16 dots.



■Stanley DN304 Ultra-High Power Infrared LED
Features ultra-high radiant power (GaAlAs type), 850nm peak wavelength, and ultra-high-speed response. The wide directivity characteristics ($\Delta\Theta = 35$ degrees) enable wide-angle radiation.



■Stanley DN305 Ultra-High Power Infrared LED
GaAlAs type LED with 850nm peak wavelength, ultra-high-speed response and narrow directivity ($\Delta\Theta = 15$ degrees). High radiant intensity ($I_E =$ 80mW/sr).



■Stanley Hi-Super Bright LED
The world's brightest LED. Continuous Liquid Phase Epitaxial Growth Technology produces the aurora-bright intensity of 3000mcd for all your outdoor displays.

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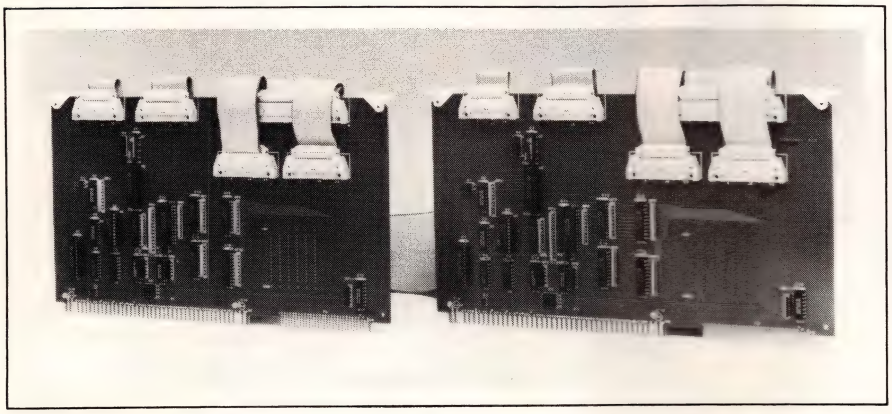
CIRCLE NO 145

NEW PRODUCTS

COMPUTERS & PERIPHERALS



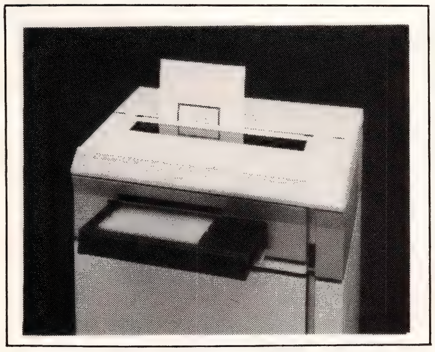
BUS EXPANSION

- *Multibus-to-Multibus interface*
- *Worst-case command time of 15 nsec*

The Syner-System Repeater 2100, a Multibus-to-Multibus, real-time interface, transmits commands from chassis to chassis in 15 nsec max. It establishes connections via five twisted-pair, flat-ribbon cables arranged in a signal/ground/signal configuration that minimizes crosstalk. IDC (insulation-displacement contact) cable headers allow you to connect the systems with FCC-approved cables. All address, data, and control signals can sink as much as 48 mA. In a system using 5-nsec transceivers, signal transfers are asynchronous and bidirectional. Worst-case system overhead is 55 nsec, excluding cable delay. The interface conforms to Multibus specification 501310, revision 04 (6/82). $1495.

HVE Engineering Inc, 1684 Dell Ave, Campbell, CA 95008. Phone (408) 370-4666. TLX 467956.

Circle No 370



PRINTER

- *Melts solid-ink pellet before printing*
- *480-dot/in. horizontal resolution*

The Model SI 480 solid-ink printer lays down 480 dots/in. in the horizontal direction when printing at 200 cps, and 240 dots/in. when printing at a speed of 400 cps. The printer, using ink that is stored as a solid pellet, achieves letter-quality printing at speeds of 200 or 400 cps. The solid-ink process melts the pellets and then fires ink through nozzles at the print target, where the ink solidifies as a fine dark dot. Two font styles come as standard offerings, and an additional library of type styles is available as an option. You can use the printer with the RS-232C and the Centronics parallel-interface protocols. Standard paper-handling capability includes automatic feeding (for cut-sheet paper) and tractor feeding. Basic unit, including automatic sheet feeder, tractors, two fonts, and two interfaces, $2795.

Dataproducts Corp, Box 746, Woodland Hills, CA 91365. Phone (818) 888-4014. TLX 674734.

Circle No 371

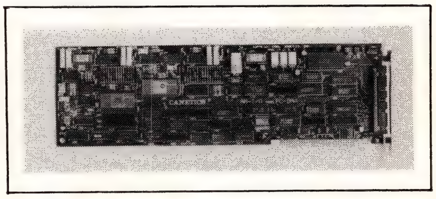
MULTIBUS COMPUTERS

- *Four 80386-based single-board computers*
- *Dual-bus structure and onboard cache increase throughput*

The iSBC 386/21, 386/22, 386/24, and 386/28 single-board computers, based on the company's 16-MHz 80386 32-bit μP, offer 1M, 2M, 4M, and 8M bytes of 32-bit memory, respectively. By using surface-mount, add-on modules, you can expand the memory to as much as 16M bytes. The increased memory provides you with direct CPU access to memory through a 64k-byte no-wait-state cache. The boards employ a dual-bus structure: a 32-bit-wide bus for data transfers between the CPU, cache, and dual-port memory; and a 16-bit bus for transfers over the Multibus or iSBX bus. The 2-bus configuration gives the boards the advantage of the high-performance, 32-bit 80386 processor and allows the boards to maintain full compatibility with the Multibus architecture. 386/21, $4800; 386/22, $5970; 386/24, $8310; 386/28, $12,990.

Intel Corp, Literature Dept, #W-332, Box 58065, Santa Clara, CA 95052. Phone (503) 640-7399.

Circle No 372

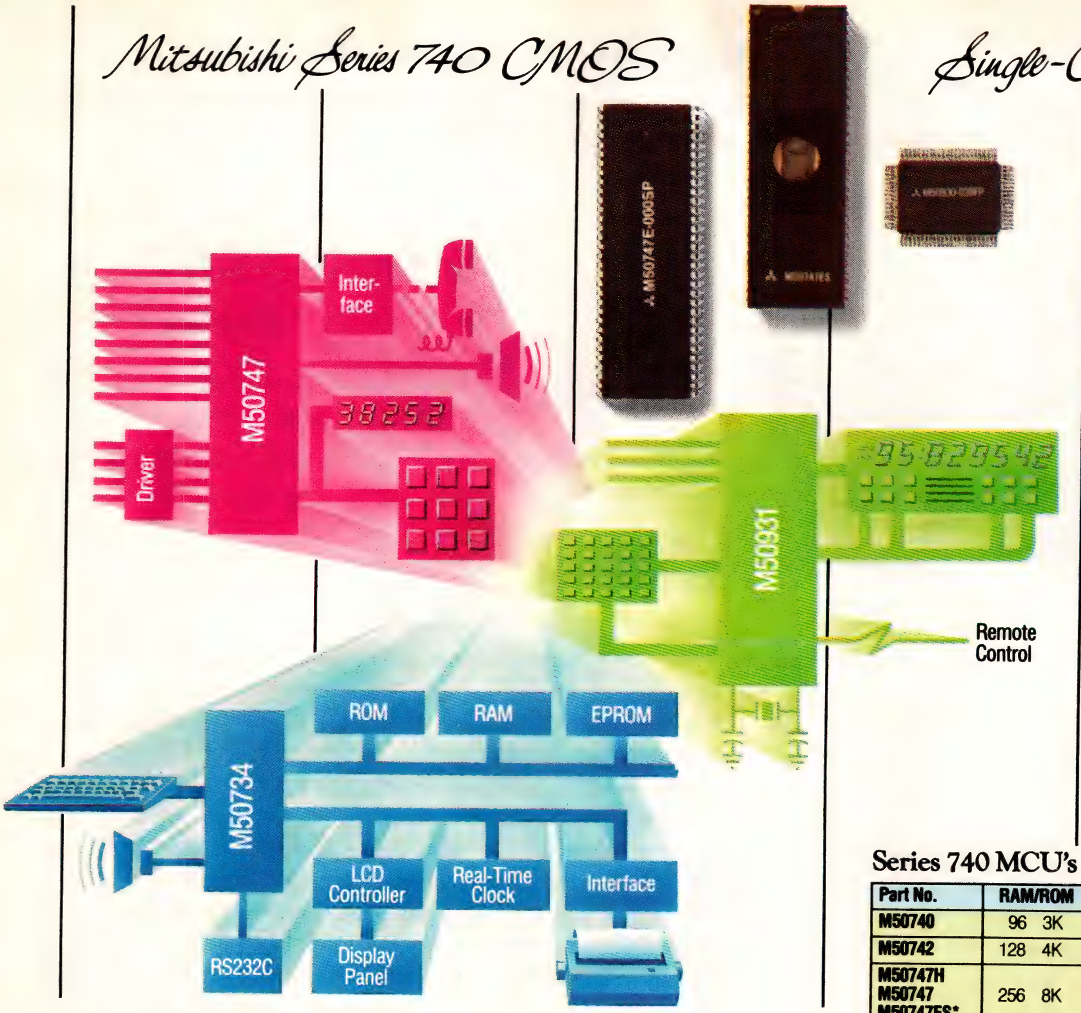


ANALOG I/O

- *Board with programmable A/D and D/A conversion*
- *Onboard filtering for anti-aliasing*

The AN-I/O Series PC-DMA board operates in an IBM PC or in compatible computers to perform 12-bit

Mitsubishi Series 740 CMOS Single-Chip MCUs



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Mitsubishi Enhances Single-Chip Solutions.

Series 740 MCU's (Partial Listing)

Part No.	RAM/ROM	I/O Lines	Key Features
M50740	96 3K	32	
M50742	128 4K	56	SERIAL I/O
M50747H M50747 M50747ES* M50747ESP**	256 8K	56	UART, SERIAL I/O
M50746 M50746ES*	144 6K	53	A/D, D/A
M50734	EXTERNAL	32, plus address and data bus	UART, A/D, STEPPER—MOTOR CONTROLLER.
M50930 M50931	128 4K 512 4K	32, plus 32 LCD segments	LCD CONTROLLER

*ES: EPROM version **ESP: One-time-programmable (OTP) version

CMOS

Fast design. Short product introduction cycles. Microcontroller performance. Optimum integration that gets your designs to market quicker than you ever thought possible.

Mitsubishi's Series 740 single-chip MCUs for telecommunications, office and factory automation, computer peripherals and consumer applications.

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The Series 740 is supported with comprehensive development systems, including software that runs on MS/DOS-based computers (IBM-PC/AT/XT™) and CP/M™ systems.

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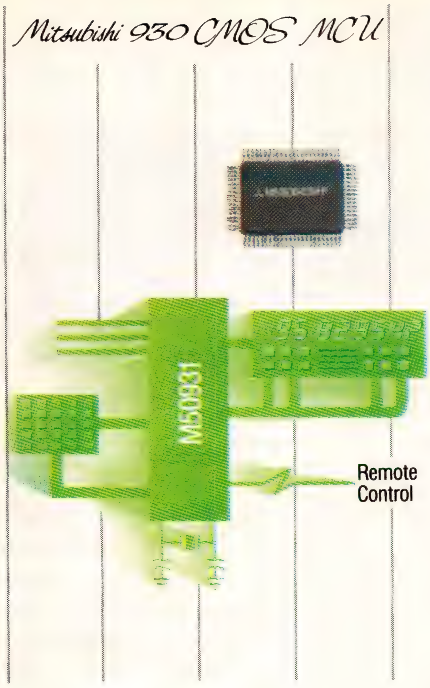
MITSUBISHI ELECTRONICS

CIRCLE NO 146



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From medical instrumentation to portable computers. They're the perfect single-chip solution. Mitsubishi's 8-bit CMOS MCUs, the M50930FP, M50931FP and M50932FP MCUs. They offer more ROM, RAM, timers and I/Os, plus easy LCD driver control up to 128 segments and low-power battery back-up (3V) operation. Ideal for portable applications.

All the subsystems you need in one 80-pin flat package for quick, cost-effective, space-saving system design.

	M50930FP	M50931FP	M50932FP*
LCD Driving Control	4 x 32		
Duty Cycle	½, ⅓, ¼		
ROM (bytes)	4K		8K
RAM (bytes)	128	512	
Memory Limit	16K x 8		
I/O Ports	32, plus 32 LCD segments		
Minimum Instruction	2 μsec		

*Under development

For single-chip solutions, call or write Mitsubishi Electronics America, Inc., Semiconductor Division, 1050 E. Arques Avenue, Sunnyvale, CA 94086. (408) 730-5900, Ext. 2314.

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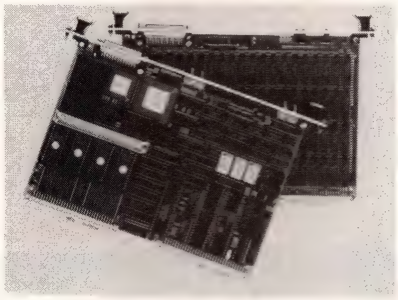
A/D and D/A conversion at rates to 100 kHz. An onboard, dual-channel DMA controller handles sample conversion. You can override the hardware timing control and execute software-commanded conversions. You can also access an input multiplexer on a channel-by-channel basis or via an autoscan approach. Also accessible through software are the gain and offset settings of an onboard instrumentation amplifier, as well as control of onboard 5-pole active filters that are used for antialiasing and signal smoothing. $1250.

Canetics Inc, Box 70459, Pasadena, CA 91107. Phone (818) 584-0438.

Circle No 373



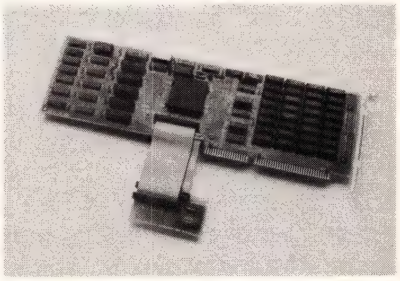
VME ENGINES

- *20-MHz, no-wait-state 68020 CPU board*
- *Lower-cost version operates at 12 MHz*

The CPU-21A 68020 CPU board, which operates at 20 MHz, increases the speed of the manufacturer's VME Bus products by as much as 20% over its other CPU boards. The CPU-21S is a lower-cost board set that operates at 12.5 MHz. All CPU-20/21 boards in the series use static RAMs, which improve performance by eliminating wait states. Using the manufacturer's local-memory interface, you can access the static RAMs located on VME Bus companion boards through a 96-pin DIN connector in the center of each board. Both boards include 512k bytes of static RAM, a 512k-byte EPROM, and a 68881 floating-point coprocessor that operates at clock rates compatible with the CPU. CPU-21S, $2995; CPU-21A, $6995.

Force Computers Inc, 727 University Ave, Los Gatos, CA 95030. Phone (408) 354-3410.

Circle No 374



ACCELERATOR

- *Speeds software for the IBM PC/AT*
- *Based on 80386 μP and high-speed cache*

The 386 Turbo accelerator card has a 1M-byte cache memory with a 100% hit rate. The cache responds to all write operations in the lower 1M byte of the memory map; consequently some software written for the IBM PC/AT and compatible computers (for example, DOS, ROM BIOS, EGA ROM) executes out of cache. You can enable read operations from the cache via software in three segments: main memory, video memory, and ROM BIOS memory. $1995.

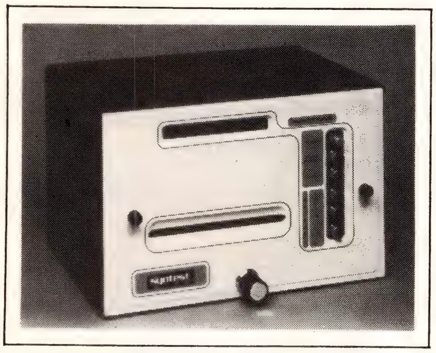
American Computer & Peripheral Inc, 2720 Croddy Way, Santa Ana, CA 92704. Phone (714) 545-2004.

Circle No 375

CONTROLLER

- *For process control and data logging*
- *Display, printer, and controller in one package*

The SP-311 Industrial Interface Station, available in panel or rack-mount enclosures, is a computer for process control and data logging. It houses a 2-color, 40-column printer;



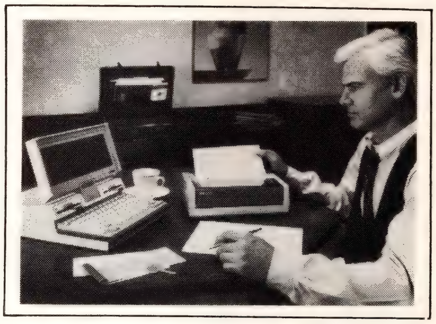
a 1×16-character, alphanumeric, backlit LCD; and three programmable pushbutton switches. An RS-232C port, a 20-mA current loop, or an 8-bit Centronics parallel input provides the interface to the station. Data rates vary from 50 to 7200 baud. A 7k-byte rotary buffer eliminates the need for an external spooler. An internal real-time clock output is available for display, for time-stamping data, or for process timing. The station measures 10.5×7×7.5 in. It operates over 0 to 50°C and accepts a 115V ac or a 12V dc input. $835.

Syntest Corp, 40 Locke Drive, Marlboro, MA 01752. Phone (617) 481-7827. TWX 710-790-7659.

Circle No 376

PRINTER

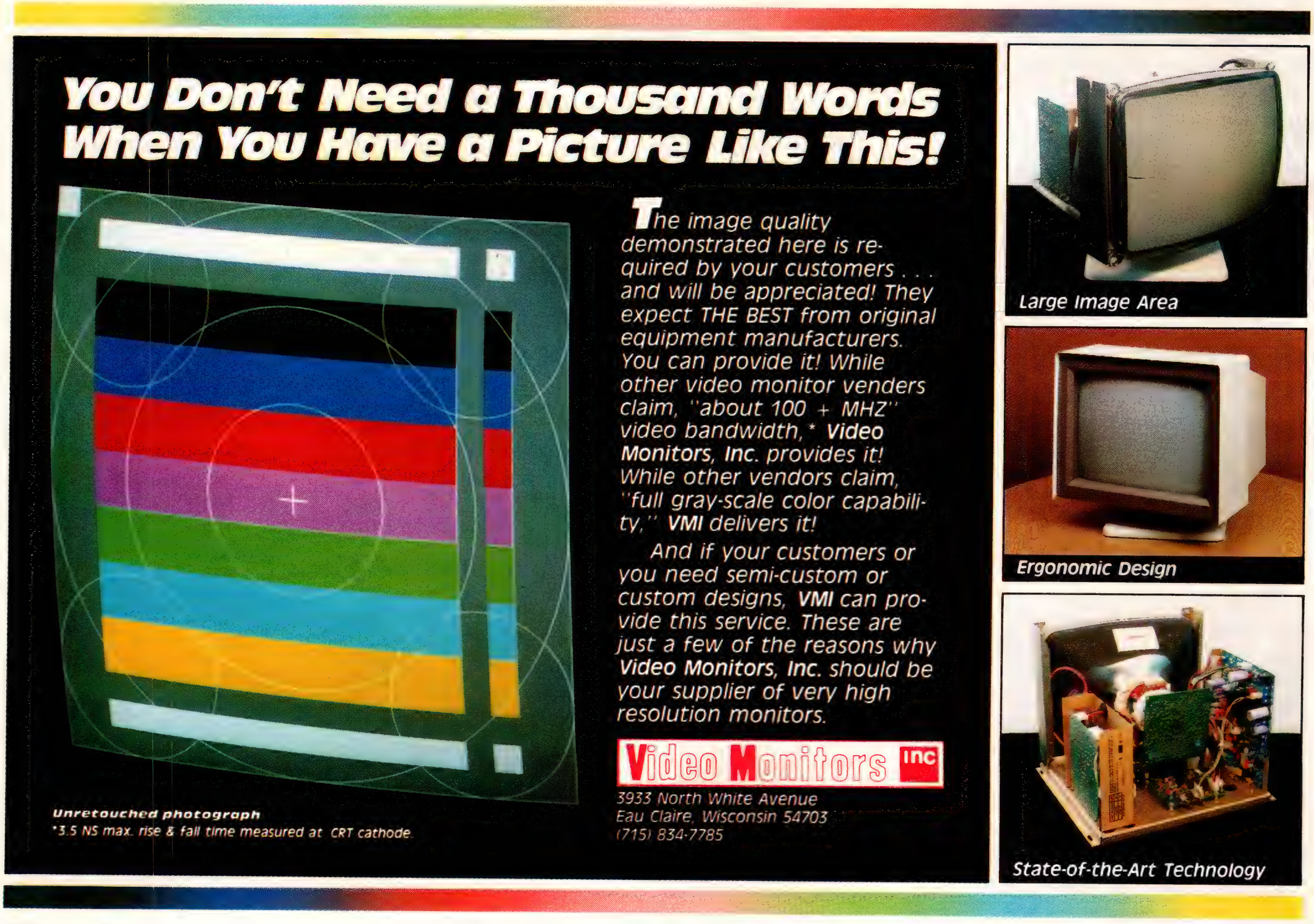
- *Battery-powered version with Centronics parallel interface*
- *Prints 200 pages between recharges*



The portable, battery-powered version of the Thinkjet printer now incorporates a Centronics parallel interface, previously available only on the ac-powered version. The printer utilizes the ink-jet method of printing; because no contact occurs between the printhead and the medium, the printing noise level is much lower than that of an impact printer. The built-in battery provides enough power to print as many as 200 pages between recharges. The printer produces 150 cps in an 11×12 dot-matrix format, and multiple print sizes are available. It weighs 5.5 lbs., measures 11.5×8.1×3.5 in., and accommodates single-sheet or tractor-feed paper. The printhead is combined in a module with the ink reservoir to simplify replacement when the reservoir runs dry. Four ink colors are available: black, blue, red, or green. $495.

Hewlett-Packard Co, 1820 Embarcadero Rd, Palo Alto, CA 94303. Phone local office.

Circle No 377



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CIRCLE NO 147

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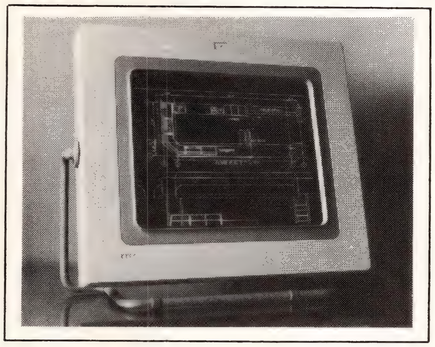


DISPLAY

- *Plasma-panel interface for IBM PC/AT and compatibles*
- *Interface includes software driver*

The PDC 100 display controller provides timing and control signals that drive the IBM 591 plasma-panel display. The controller operates with an IBM PC/AT or with compatible computers and includes a PC/AT interface, a program RAM, an 8086 μP, an 82786 graphics-controller chip, a screen-image RAM, and the plasma-panel interface. You can download graphics commands and routines to the program RAM, or you can issue commands directly to the 82786 graphics coprocessor. The 512k bytes of image RAM that's available corresponds to five separate bit maps. All the buffers and control circuitry required by the plasma display are included on the board. Interface board with 82786 chip and plasma panel, $4700.

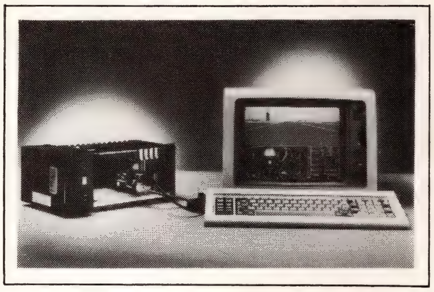
Infograph Inc, 331 Rio Grande St, Suite C, Salt Lake City, UT 84101. Phone (801) 521-0079.

Circle No 378

VIDEO CONTROLLER

- *EGA video controller for STD Bus*
- *Combines capabilities of the EGA, CGA, and MDA*

The ZT 8844 EGA video graphics controller (VGC) provides compatability with the IBM Enhanced Graphics Adapter (EGA) for STD-8088 systems. You can use the VGC to display scientific and process-control information from STD Bus environments. The capabilities of the EGA, IBM's Color Graphics Adapter (CGA), its Monochrome Display Adapter (MDA), Hercules Monochrome Graphics, and Plantronics's Colorplus mode all reside within the controller. Running under the STD DOS and STD MultiDOS operating systems, the VGC combines the card and operating systems and provides access to the library of PC-DOS-compatible graphics programs. The controller can sense whatever mode is required by the application software and automatically switches between modes such as EGA and CGA. ZT 8844 with BIOS EPROM, $565.



Ziatech Corp, 3433 Roberto Ct, San Luis Obispo, CA 93401. Phone (805) 541-0488. TLX 4992316.

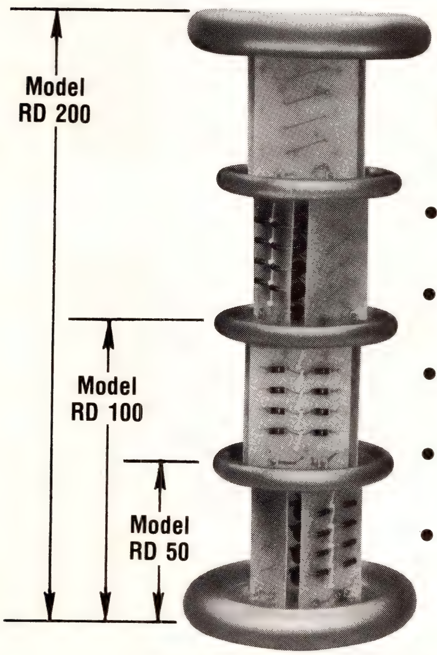
Circle No 379

VME CONTROLLER

- *DMA-driven peripheral controller*
- *Controls eight SCSI initiator or target devices*

The VSCSI is a single-board VME Bus controller that can drive eight SCSI devices, such as cartridge tape drives, hard disks, floppy disks, optical memories, and printers. The board has a 10-MHz 68000 μP that operates with no wait states, 512k bytes of dual-port RAM with parity-error checking, and a 64k-byte EPROM. An NCR 5380 SCSI controller, coupled with a pro-

NEW precision instrument for voltage measurement of high voltage D-C power supplies that also measures A-C ripple component



- Three models rated at 50, 100, 200 KVDC max
- Measurements accurate to 0.25% of full scale
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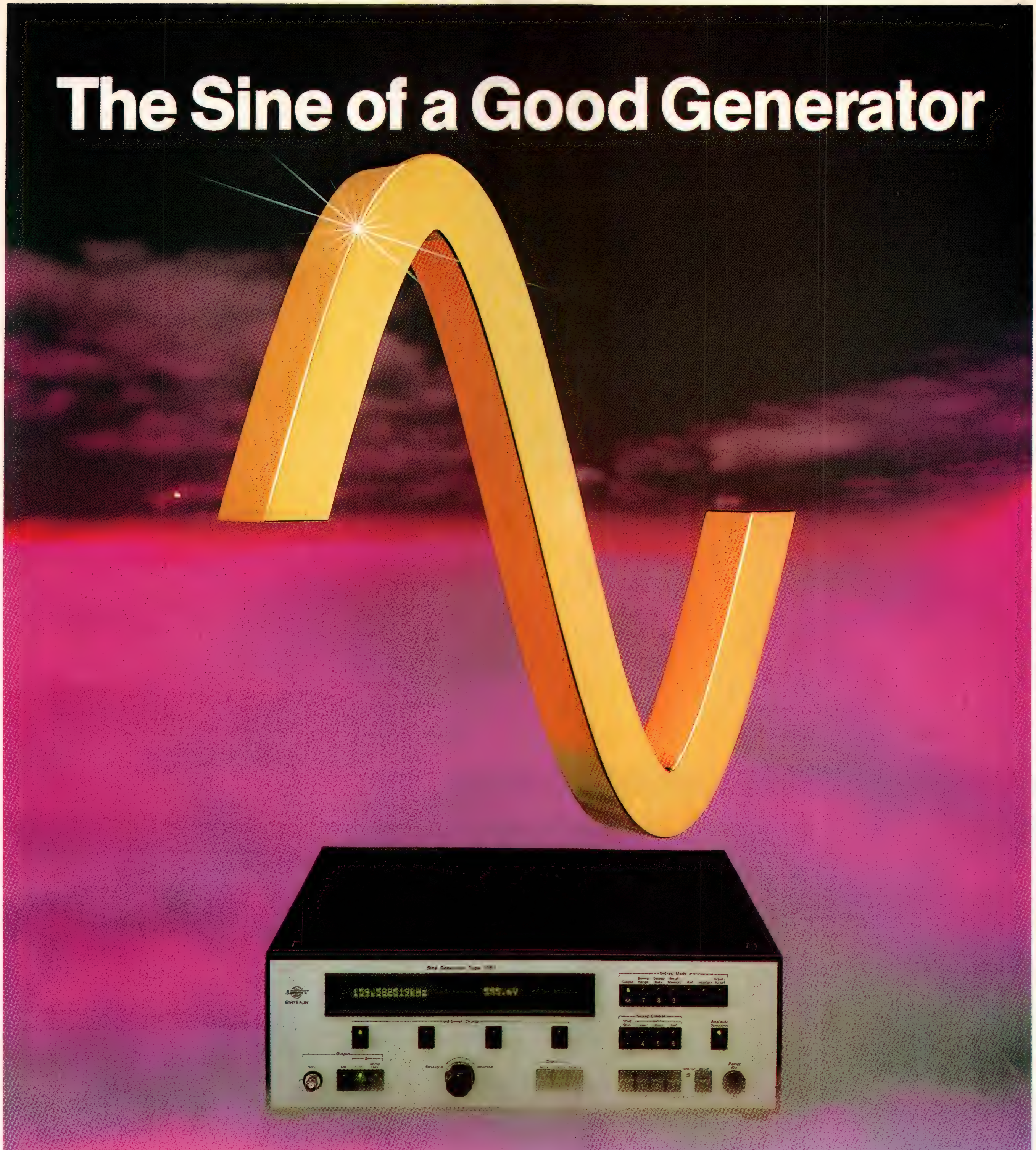

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MI (313) 522-8600 · IL (312) 358-7582 · TX (713) 645-0167 · CA (714) 978-8066 · (415) 574-8155 · WA (206) 625-1112

86-460

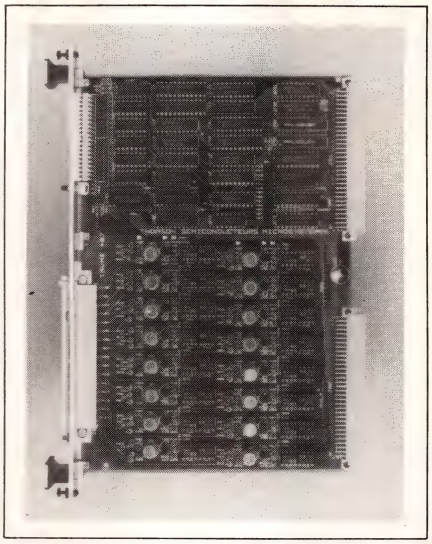
prietary DMA engine that allows 16-bit interrupt-driven DMA transfers anywhere in local or VME address space, is also part of the package. The board supports 1.5M-bps asynchronous data transfers and has a burst transfer rate of 4M bps When you add a serial interface board, the VSCSI can also act as a VME Bus master. $1785.

Dual Systems Corp, 2530 San Pablo Ave, Berkeley, CA 94702. Phone (415) 549-3854.

Circle No 380

OUTPUT BOARD

- *Provides 16 isolated 60V/2A open-drain outputs*
- *Has optocouplers to help you read back actual output status*



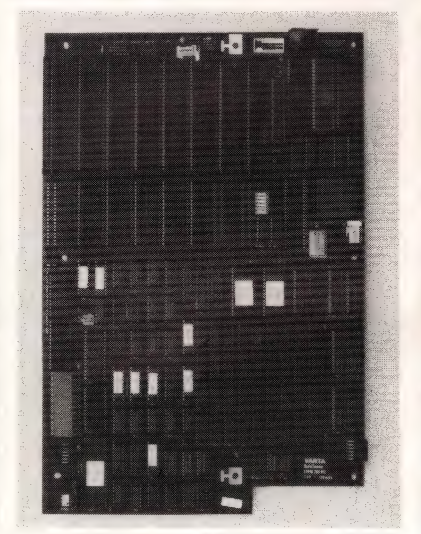
The TSVME-407 is a double-Eurocard VME Bus board that provides you with 16 open-drain isolated outputs capable of switching currents as high as 2A. The outputs have a nominal operating voltage range of 12 to 60V; the breakdown voltage is 100V. Isolation between the outputs and the VME Bus ground is 1500V, and isolation between individual outputs is also 1500V. Additional optocouplers allow you to read back the actual status of individual outputs, and an automatic survey mode generates a VME Bus interrupt if the actual output states and the programmed states differ. You can program the interrupt level and interrupt vector. The slave VME Bus interface occupies four 16-bit words of address space. The board has 16 channel-status LEDs on its front panel. Fr fr 10,300.

Thomson Semiconducteurs, 43 Ave de l'Europe, 78140 Velizy, France. Phone (1) 39469719. TLX 204780.

Circle No 381

Thomson Components-Mostek Corp, 7950 E Redfield Rd, Scottsdale, AZ 85260. Phone (602) 951-2900.

Circle No 382



1-BOARD COMPUTER

- *Provides IBM PC/AT-compatible environment for MS-DOS 3*
- *Includes a power-fail nonmaskable interrupt*

The Kat-Board is an 80286-based single-board computer that provides an IBM PC/AT-compatible environment for running MS-DOS version 3. The processor normally operates at 10 or 12 MHz, but you can switch it via software to an IBM PC/AT-compatible 6-MHz, 1-wait-state mode. The computer is equipped with 1M byte of parity-checked,

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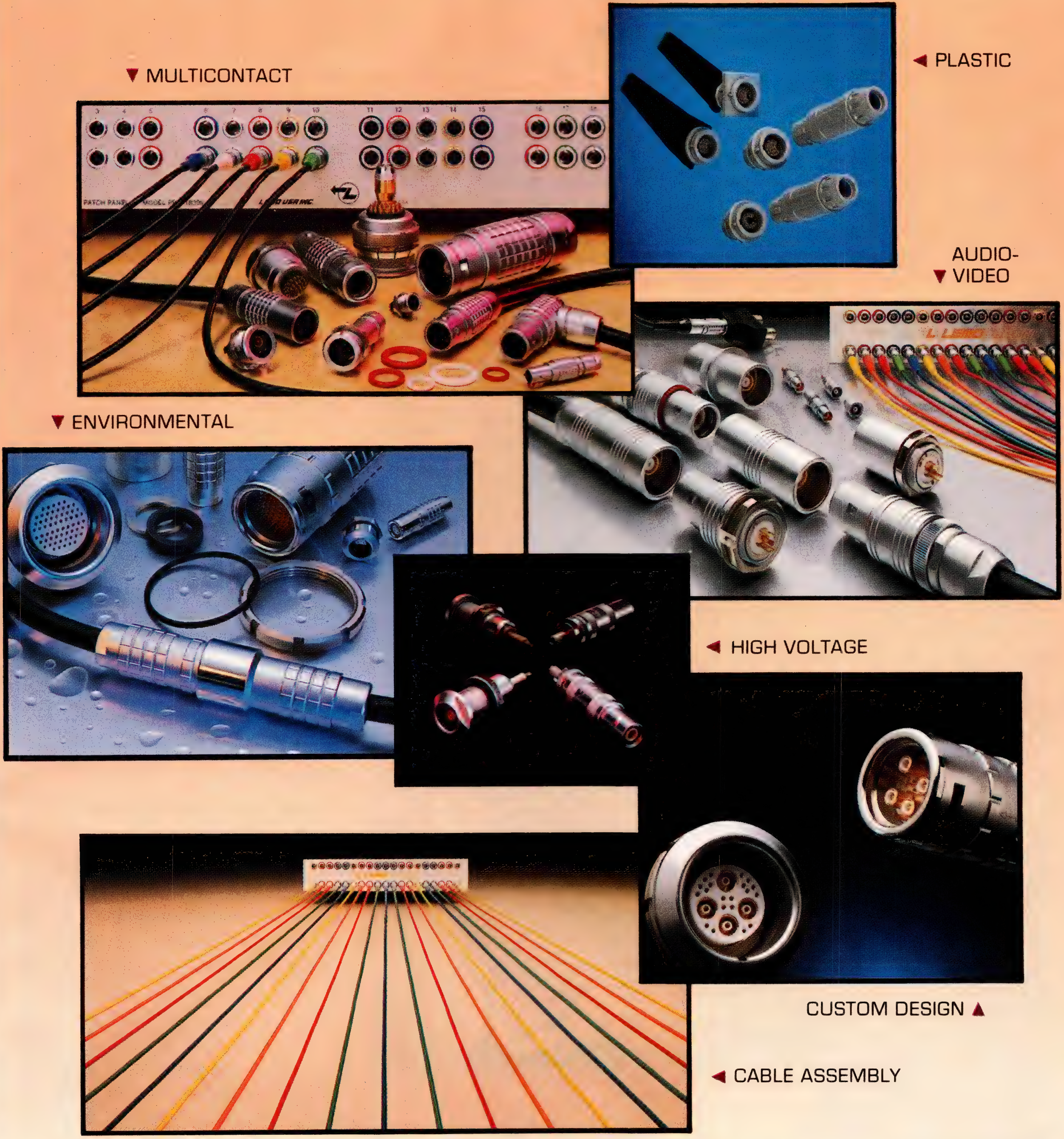

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CIRCLE NO 152

zero-wait-state dynamic RAM (which you can upgrade to 4M bytes); you can also purchase the board with as much as 512k bytes of static RAM. The board can address 16M bytes of memory. Two onboard sockets for EPROMs have capacities as high as 512k bits. The board comes with a battery-backed, real-time clock/calendar, a 64-byte CMOS RAM, and a socket for an 80287 math coprocessor. The 80286 CPU has a nonmaskable interrupt for parity errors in the system RAM, for an offboard interrupt, and for power-supply failure. It also has two interrupt-controller chips for a total of 16 maskable interrupts. Additional onboard support includes a serial data keyboard controller, a timer/counter, a speaker output, and control/status ports. The board requires 5, 12, and −12V supplies and consumes approximately 4A from the 5V supply. It is supplied with an MS-DOS 3 diskette and a compatible ROM BIOS. DM 2600 (100).

Kontron Mikrocomputer GmbH, Oskar-von-Miller-Strasse 1, 8057 Eching, West Germany. Phone (08165) 770. TLX 526719.

Circle No 383

Kontron Electronic Inc, 630 Price Ave, Redwood City, CA 94063. Phone (415) 361-1012.

Circle No 384

- High resolution, 1280 x 1024 pixels. Command settable raster parameters. Up to 64 MHz.
- Hitachi HD63484 ACRTC with enhanced graphic drawing commands - line, rectangle, circle, polygon, ellipse, arc, filled rectangle, paint, pattern, copy etc.
- Drawing speed up to 500 ns per pixel for monochrome or color application.
- 4 bit (16 colors) per board. Expandable up to 65.536 colors through 3 slave-boards.
- 8 bit video DAC with programmable color look-up table (max. 256 colors out of 250.000) available as piggyback.
- 512 K byte (= 1 Mpixel) dual ported on-board RAM.
- Independent X and Y zoom-factors.
- Interlaced or non-interlaced operation.
- Lightpen input.
- 32 bit interface
- Programmable attributes: Blink background color, maskable planes, inverted video, interrupt on VSYNC.
- Configurable output: RGB, RS 343A, RS 170 and others.
- Hardware crosshair cursor.
- 3 high speed hardware selectable horizontal split screens. Unlimited software split screens.
- High speed hardware selectable window. Selectable modes: Transparent, overlay, blink. Unlimited software windows.
- Planes configurable for blink with programmable background colors.

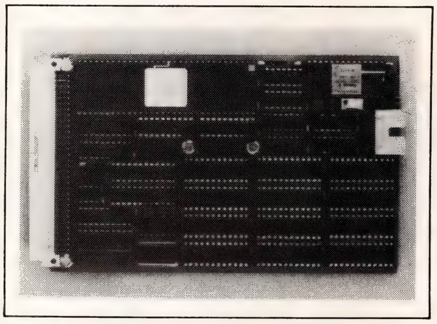
Software:

- OS-9 driver software available.
- GKS implementation soon.

Marketed in the US by: Dage Precision Industries Inc.
PO Box 120A, Santa Clara CA 95052, Ph. (408) 727-1932

European Headquarters: MicroSys GmbH, Anzinger Str. 1
D-8000 Munich 80, Ph. (89) 63801-0, TLX 5213288 mibad

CIRCLE NO 154



GRAPHICS CONTROLLER

- *For the G64 Bus*
- *Displays 256 colors from a palette of 262,144*

The GESVIG-4 display controller is a G64 Bus-compatible card that comes on a single-height Eurocard and displays as many as 640×480 pixels on a noninterlaced screen. You can display 256 colors from a palette of 262,144. The controller can draw at a rate of 2.5 million pixels/sec and supports vector and circle drawing as well as pattern filling, zooming, and windowing. The controller is supported by a VDI-compatible software driver, the GESGPS-3, which operates in Microware's (Des Moines, IA) OS-9, a 68000-based operating system. GESVIG-4, $1250; GESGPS-3, $250.

Gespac Inc, 100 W Hoover Ave, Mesa, AZ 85202. Phone (602) 962-5559.

Circle No 385

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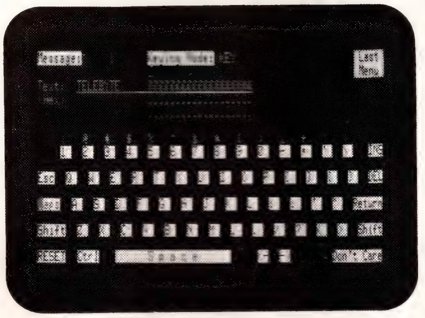

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Netscope is the only data line monitor for under $2000 which offers:

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- soft QWERTY and hex keyboards;
- 0-to-56K baud monitor with 19.2K baud emulate and test data rates;
- non-volatile memory for configuration, messages and test;
- 16 line by 64 character display on 5″ CRT;
- easy field upgrades of operating system through chip replacement; and
- optional light pen for faster instruction input.

Netscope's versatility allows you to position it between DCE and DTE devices or in a T connection in field applications. RS-170, printer and storage ports are available as options.

No other data line monitor offers as much in features and performance as the Telebyte Netscope for so little money. And it only weighs 12 pounds.

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CIRCLE NO 155

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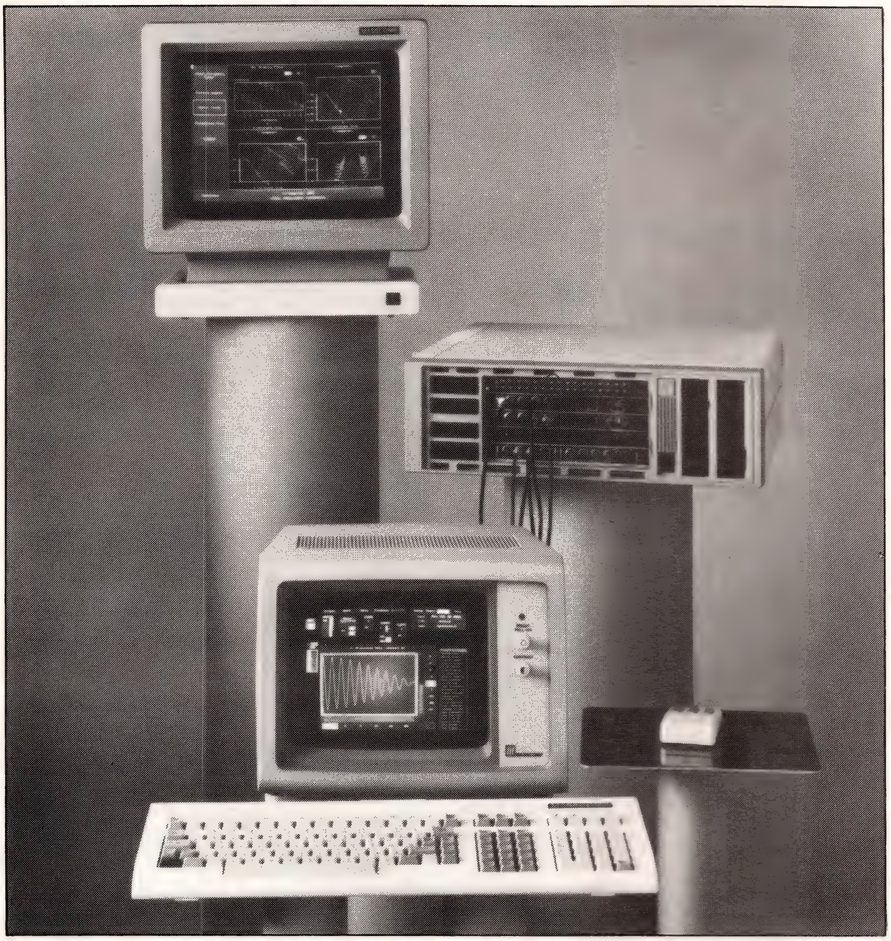
CIRCLE NO 153

NEW PRODUCTS

CAE & SOFTWARE DEVELOPMENT TOOLS



UNIX LAB SYSTEM

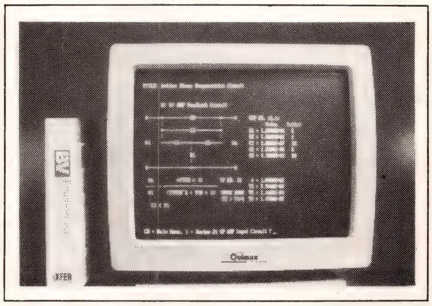
- *Designed for scientific laboratory applications*
- *Features enhanced Unix and menu-driven software*

The Scientific Laboratory System (SLS) features a 32-bit, proprietary memory bus that can transfer data between memory and the 68020 CPU at speeds as high as 12M bytes/sec. A hardware bus adapter allows DMA data transfers between memory and a Multibus at speeds as high as 6M bytes/sec. You can connect STD+Bus peripherals to the Multibus through a data-acquisition control processor that allows data transfers between the STD+Bus and the Multibus at 2M bytes/sec max. The memory-management unit provides each process with virtual addressing of 128M bytes max for system use and 128M bytes max for user space. An 8k-byte, write-through cache maintains no-wait-state performance by means of virtual addressing and direct mapping. An MC68881 floating-point coprocessor performs mathematical operations at more than 1.1 million Whetstones/sec; you can add the vendor's Lightning accelerator board to raise the performance to more than 3 million Whetstones/sec. The SLS comes with a 650k-byte floppy-disk drive and a 71M-byte hard-disk drive, both of which use the SCSI interface and transfer data at speeds as high as 1.5M bytes/sec over the SCSI bus. The built-in graphics hardware provides resolutions of 1152×910 pixels (monochrome) or 640×480 pixels (color).

The RTU operating system is a Unix System V implementation enhanced for fast, real-time data acquisition and instrument control. The system comes with the vendor's Laboratory Workbench, a menu-driven package that features pull-down menus, pop-up displays, icons, and interactive controls. From $29,000.

Masscomp, 1 Technology Park, Westford, MA 01886. Phone (617) 692-6200. TLX 704353.

Circle No 386



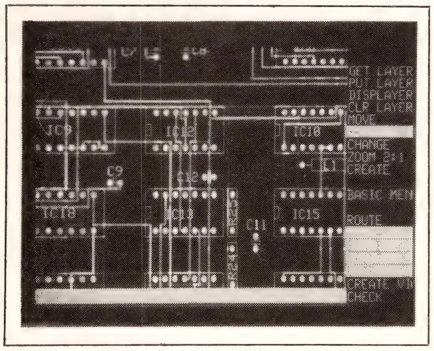
FUNCTION ANALYSIS

- *Computes circuit values for a desired op-amp transfer function*
- *Performs sensitivity and Monte Carlo analyses*

The XFER transfer-function analysis and synthesis program runs on IBM PCs and compatible machines. Given an op-amp circuit configuration and the values of the circuit elements, the program computes the circuit's transfer function. Conversely, the program can use short-circuit transfer impedance functions around an op amp to compute the circuit configuration and element values that will synthesize a desired transfer function. Because the program divides the forward and feedback elements of op-amp configurations into multiple short-circuit transfer impedance functions, you can synthesize or analyze almost any transfer function that has real roots. The menu-driven program also computes the magnitude- and phase-response of a given circuit, and allows you to perform sensitivity and Monte Carlo analyses. $72.95.

BV Engineering, 2200 Business Way, Suite 207, Riverside, CA 92501. Phone (714) 781-0252.

Circle No 387



MULTILAYER CAE

- *Permits design of boards with as many as 26 layers*
- *Enhanced capabilities for surface-mount design*

EE Designer II provides all the functions of the earlier version for schematic capture, circuit simulation, and pc-board layout, but employs a new graphics kernel and adds a variety of layout- and schematic-design enhancements. These enhancements include the ability to create ground planes on either side of a pc board and to display multilayer layouts. Layout enhancements allow you to define trace widths and pad sizes, to select both 5- and 12.5-mil grid spacing, and to perform block deletes, macro saves, and multistep pan. Schematic-capture enhancements include orthogonal rubberbanding. The package comes with a starter library of surface-mount components, and the enhanced drawing package now allows you to create new components and pad shapes. The library-management facilities include browse, fetch, and mirror operations. You can dump plotter files and numeric-control drill files to disk; you can also create generic plot files in ASCII format, containing absolute X and Y coordinates, which facilitate the writing of customized plotter driver routines. The program runs on IBM PC/XT, PC/AT, and compatible machines. $1875.

Visionics Corp, 1284 Geneva Dr, Sunnyvale, CA 94089. Phone (408) 745-1551. TLX 346352.

Circle No 388

C INTERPRETER

- *Full-screen, memory-resident editor for correcting source code*
- *Resident debugger checks source code on exit from editor*

Instant-C 2.0 is an enhanced version of a C-language interpreter/compiler that runs on the IBM PC and compatibles. The enhancements include implementation of all the features specified by Kernighan & Ritchie, the ability to link object code from Lattice and Microsoft libraries, a full-screen editor, and a run-time checker that checks for invalid or null pointer references and array subscripts. After each editing session, the program checks your program for syntax errors; if it finds any, it displays them, one at a time, on the same screen as the source code, with the cursor positioned at the problem area. You can immediately make your corrections with the editor, and the compiler then operates only on the changed portions of code, thereby speeding up the recompilation process. The enhanced debugging facilities now let you work directly with the source code. You can set breakpoints anywhere in your program; at any breakpoint you can display the values of variables and data and call or edit other C functions. The package contains a new dynamic linker that allows you to make use of the many commercially available libraries of C routines and functions. $495.

Rational Systems Inc, Box 480, Natick, MA 01760. Phone (617) 653-6194.

Circle No 389

SOLID MODELER

- *Runs on IBM PC/AT and compatibles*
- *Allows sectioning and viewing from any point in 3-D space*

RoboSOLID is a fast, solid-modeling program that runs on the IBM PC/AT and compatible machines. The program processes a 2-dimensional drawing that you have produced with the aid of the built-in 2-dimensional drafter; alternatively, you can import a file generated by the vendor's RoboCAD, Autodesk's AutoCAD, or by any DXF-compatible CAD system. The program generates solids by extruding or turning profiles; you can assemble complex shapes from any number of individual solid elements using the Boolean operations Intersect, Unite, and Subtract. You can section the model and then view it from any point in 3-dimensional space; you can choose the viewing distance, select axonometric or perspective presentation, and display or remove hidden lines. You can then export views of the sectioned model to any DXF-compatible CAD system for dimensioning, plotting, and other operations. To run the program, you need an IBM PC/XT, PC/AT, or compatible machine, 640k bytes of RAM, a hard-disk drive, and a Hercules monochrome or EGA color graphics adapter. $1095.

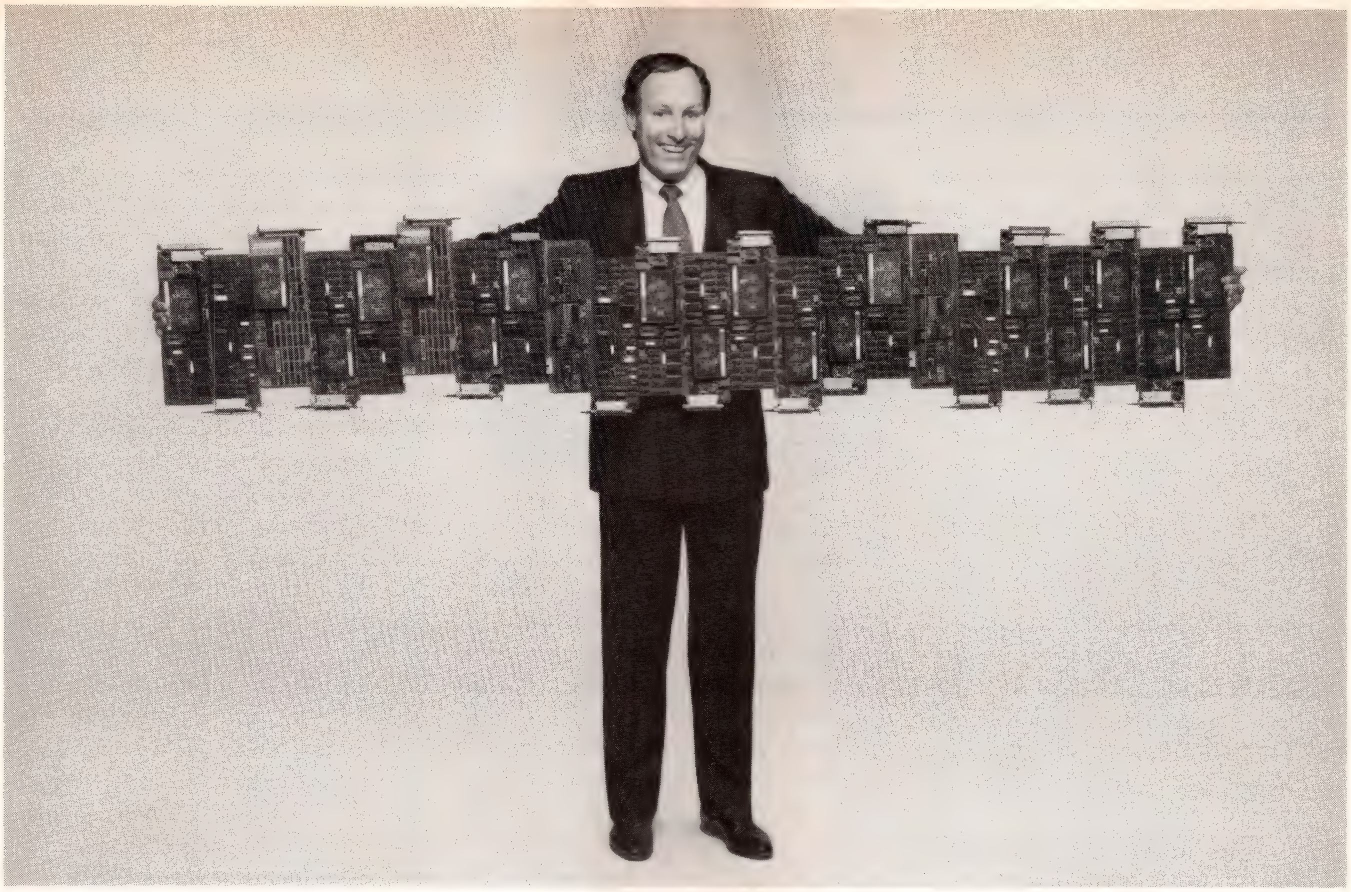
Robo Systems Corp, 3000 Cabot Blvd W, Ste 150W, Langhorne, PA 19047. Phone (215) 750-6990.

Circle No 390

GRAPHICS DATABASE

- *Conforms to PHIGS draft standard*
- *Provides device-independent output*

The DI-3000XPM is a graphical data-management package for 2- and 3-dimensional modeling, design, and simulation applications. It operates in conjunction with the vendor's AddSys-3000 subroutine li-



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See the chart for details and remember: Fred Molinari will go to any lengths to provide the boards you need.

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	Model	Price (U.S. $)	Channels	Resolution (Bits)	Speed (kHz)	Channels	Resolution (Bits)	DIO (lines)	Clock	Terminal Panel
General Purpose	DT2801	995-2070	4-16	12-16	13-27	2	12	16	Yes	DT707
	DT2806	295	to 80	12	20	to 24	12	to 72	Yes	DT757
	DT2808	495	16	10	3.3	2	8	16	Yes	DT707
Low Cost	DT2814	395	16	12	25	–	–	–	Yes	DT757
	DT2815	499	–	–	–	8	12	–	–	DT757
	DT2817	199	–	–	–	–	–	32	–	DT758
High Speed	DT2821	1345-2495	4-16	12-16	50-130	2	12	16	Yes	DT707

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CIRCLE NO 156

brary, which matches the data-management package to a series of Tektronix (Beaverton, OR) graphics terminals. Together, the data-management package and the subroutine library provide a comprehensive set of tools for developing device-independent graphics application programs. You can build and manipulate logical objects in a graphics database that is modeled on the most recent version of the PHIGS (Programmer's Hierarchical Interactive Graphics) draft standard. The package includes a hidden-line removal utility that processes complex models and generates device-independent line output. You can traverse the database one object at a time for visual debugging of complex structures. A quick-view option provides screen display or hard-copy snapshots of the models. The built-in subroutine library allows you to send this output to any one of more than 100 graphics terminals and hard-copy devices or, with the aid of the AddSys-3000 library, to Tektronix Series 4100 graphics terminals. From $2700 for a MicroVAX II version running under VMS; AddSys-3000, from $1000.

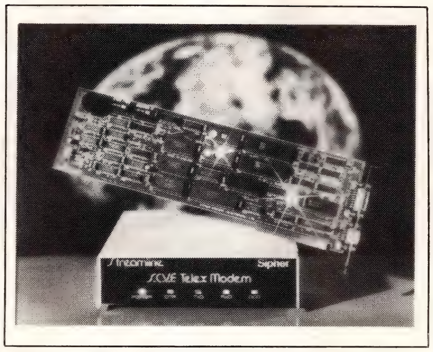
Precision Visuals Inc, 6260 Lookout Rd, Boulder, CO 80301. Phone (303) 530-9000. TLX 450364.

Circle No 391

TELEX PACKAGE

- *Available as a PC-based or stand-alone unit*
- *Controls outgoing and incoming telex as a background task*

Available as an add-in for the IBM PC, PC/XT, PC/AT, or compatible computers, or as a stand-alone unit operating via an RS-232C interface, the pcStreamline provides on-line access to the telex network. Communication facilities include an on-line conversational mode; multiple message queues and prioritization of outgoing telexes; automatic retry on busy or degraded telex connections; and batching of telexes destined for the same telex address. The unit also time-stamps and date-stamps telexes, sends telexes to multiple telex numbers, and performs short-code dialing. You can also set up telex directories and store incoming messages directly to disk. An onboard processor and 32k bytes of RAM allow the unit to control telex operations as a background task; battery backup for the RAM ensures that messages are not lost during power failures. You can generate outgoing telexes on any text-oriented software package, and the unit automatically performs character expansion, substitution for illegal telex characters, and word-wrapping on message lines that exceed a given length. When connected to multiple telex networks, pcStreamline can automatically select the most cost-effective network for message transmission. PC add-in, complete with telex modem, £1495; stand-alone unit, £1695.



Streamline Datacom Ltd, Unit 14, St George's Industrial Estate, White Lion Rd, Amersham, Bucks HP7 9JQ, UK. Phone (02404) 5500. TLX 83293.

Circle No 392

GRAPHICS FOR DBMs

- *Math and stat functions let you create new data relationships*
- *Allows simultaneous display of multiple graphs*

R:BASE Graphics operates in conjunction with the vendor's R:BASE database-management systems running on IBM PC, PC/XT, PC/AT and compatible machines, in both single-user and LAN configurations, including the IBM Token Ring Network. The graphics package uses a data-collapsing procedure that reduces thousands of values to a graphable subset, and thus can present usable information from very large databases. You can display the information in eight different formats: pie, line, column, bar, hilo, area, scatter plot, and mixed. You can display multiple graphs simultaneously on the screen; 16 colors and 6 different fonts allow you to make each one distinctive for easy comparison. For single-user operation, you'll need DOS 2.0 or higher and at least 512k bytes of RAM; for network operation, you must have DOS 3.1 and at least 640k bytes of RAM. $295.

Microrim, Box 97022, Redmond, WA 98073. Phone (206) 885-2000.

Circle No 393

WORKSTATION

- *Performs 5 million gate evaluations per sec*
- *Simulates systems with as many as 1 million gates*

CoSim II is a simulation-accelerating computer that resides in an Apollo workstation network. It is a proprietary RISC (reduced-instruction-set computer) that simulates responses to a stream of data, representing real instructions, at rates as high as 5 million gate evaluations per sec; you can simulate multiboard, multichip digital systems that have as many as 1 million gates. The accelerator forms part of the company's design system, which uses both software constructs and hardware coprocessors to achieve a level of performance that, according to the vendor, was not previously possible on mainframe-based CAE systems. $85,000.

AIDA Corp, 3375 Scott Blvd, Suite 340, Santa Clara, CA 95054. Phone (408) 748-8571.

Circle No 394

Forty Years of Fan Manufacture Have Taught Us One Thing:

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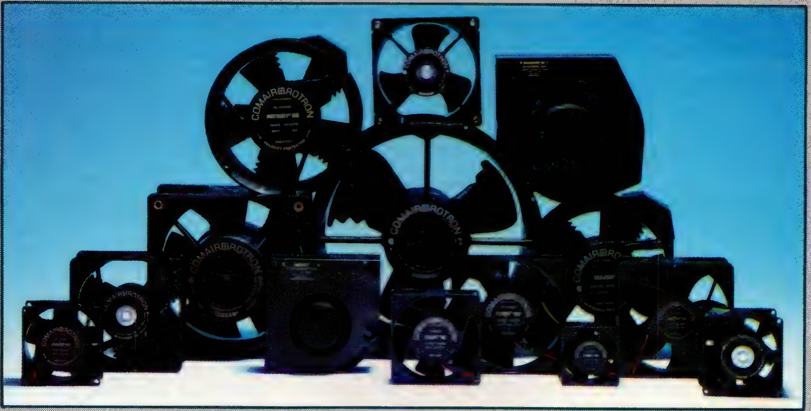
. . . Or Sprints®, Whispers®, Caravels®, Sprites®, Patriots®, Majors®. . . or any of the benchmark fans Rotron has created over the last four decades as the world pioneer in fan design and manufacture.

We're Comair Rotron, proud heir to the unparalleled history of forced convection cooling fans that bear the Rotron name.



Our new company is built around our *only* business: fans and blowers for commercial cooling applications.

Would You Trade Your Computer for an Abacus?

Hardly. Then why specify a fan as an add-on to your carefully designed computer, power supply or other machine when, with Comair Rotron's help, you can design a forced convection cooling unit *into* your system?

We're committed to providing the design engineer with the tools to efficiently and cost-effectively integrate component cooling, rather than add it later.

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On your test track, or, when the need arises, on ours.

At Comair Rotron's world headquarters in Saugerties, NY, we maintain the finest laboratory and testing facilities in the industry.

Many of our fans have been on life-test equipment for more than ten years.

And when you design a Comair Rotron fan into your computer, power supply or other system, we'll be happy to live-test it for you, to make certain the results you need are the results you get.

Of course, our experienced Application Engineers are only a telephone call away, ready to aid you in finding the precise fan for your most exacting requirements.

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Since the Rotron name first appeared, we have manufactured more than 100 million fans for commerce and industry. No other company even comes close . . . in design, engineering or manufacturing expertise.

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CIRCLE NO 169

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Product	Part No.	Orgn.	Access Time (ns)	Packaging
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16K SRAM	HY61C16A	2Kx8	25,35,45,55,70	24-pin DIP (300/600)
16K SRAM	HY61C67	16Kx1	25,35,45,55,70	20-pin DIP (300)
16K SRAM	HY61C68	4Kx4	25,35,45,55,70	20-pin DIP (300)
16K SRAM	HY61C69	4Kx4	25,35,45,55,70	22-pin DIP (300)
64K SRAM	HY62C64	8Kx8	100,120,150	28-pin DIP (600)
64K SRAM	HY62C64A	8Kx8	35,45,55,70	28-pin DIP (600)
64K SRAM	HY62C87	64Kx1	35,45,55	22-pin DIP (300)
64K SRAM	HY62C88	16Kx4	35,45,55	22-pin DIP (300)
256K SRAM	HY62C256	32Kx8	55,70,90	28-pin DIP (600)

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CIRCLE NO 157

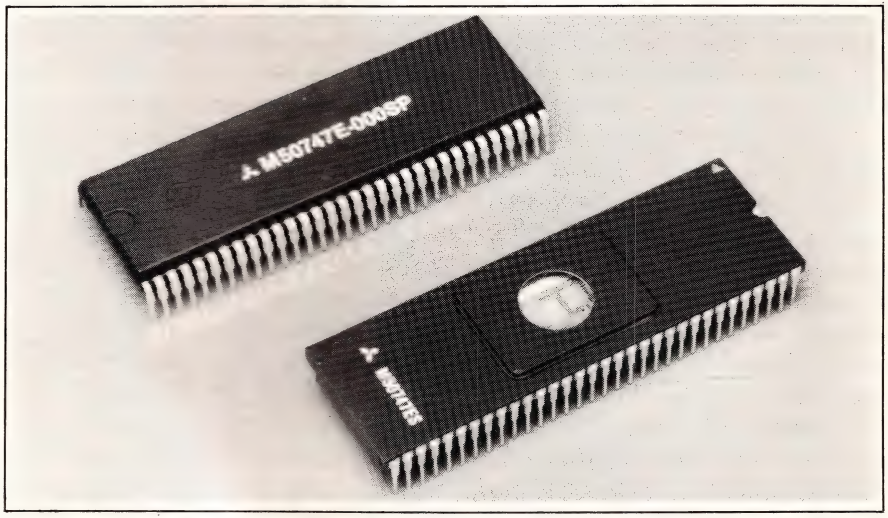
NEW PRODUCTS

INTEGRATED CIRCUITS

MICROCONTROLLER

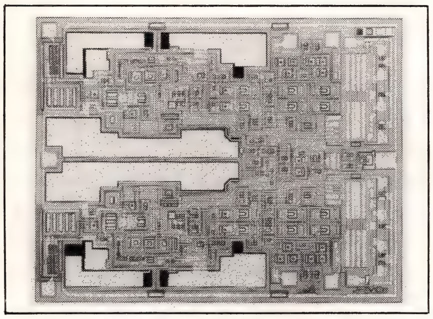
- *Offers 8k bytes of on-chip EPROM*
- *Available in one-time-programmable version*

The Model M50747ES microcontroller contains 8k bytes of EPROM. The μC is available in a version that uses a glass-windowed ceramic DIP, or in a one-time-programmable version in a plastic DIP. Both DIPs have 64 pins. You can also obtain the μC in a 72-pin quad flat pack. You can operate the devices in any of four modes: microprocessor, memory-expansion, single-chip, or evaluation. The IC has 256 bytes of RAM, an on-chip UART, three 8-bit timers, two prescalers, and 56 I/O lines. Development tools include software that runs in MS-DOS and CP/M systems, and in-circuit emulator boards and debugging units. $45.50; one-time-programmable version, $20.25 (100).



Mitsubishi Electronics America Inc, 1050 East Arques Ave, Sunnyvale, CA 94086. Phone (408) 730-5900.

Circle No 399



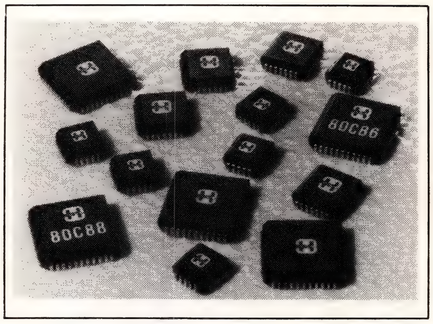
DUAL OP AMP

- *Specs low noise, high bandwidth*
- *Housed in miniature 8-pin DIP*

The Model RC4227 precision dual operational amplifier has a typical input offset voltage of 20 μV and typical input bias current of ±12 nA. The op amp provides an undistorted output of 7V p-p at 100 kHz. Speed parameters include an 8-MHz gain-bandwidth product and a 2.7V/μsec slew rate. Typical dc specs include 800,000V/V open-loop gain, 120-dB common-mode and power-supply rejection, and 0.3-μV/°C offset-voltage drift. The device's noise spec is 80 nV p-p over the range 0.1 to 10 Hz. Available in 8-pin ceramic or plastic DIPs, the op amps come in versions for both the commercial (0 to 70°C) or military (−55 to +125°C) temperature ranges. Commercial version, $0.91 (100).

Raytheon Co, Semiconductor Div, 350 Ellis St, Mountain View, CA 94043. Phone (415) 966-7639.

Circle No 400



CMOS μP FAMILY

- *Includes μPs and support ICs*
- *Comes packaged in PLCCs*

This family of 13 CMOS peripheral and bus-support devices complements the manufacturer's 80C86 and 80C88 μPs. Housed in PLCCs, the ICs are available in both commercial (0 to 70°C) and industrial (−40 to +85°C) versions. The family comprises a DMA controller, a serial datacomm IC, a programmable UART, a timer/counter, a parallel-I/O device, an interrupt controller, two octal latching bus drivers, a clock generator, a static clock controller, two data-bus transceivers, and a bus controller. Prices for the commercial-grade parts range from $6.44 to $33.45; for the industrial-grade devices, from $9.82 to $34.78 (100).

Harris Corp, Semiconductor Sector, Box 883, Melbourne, FL 32901. Phone local office.

Circle No 441

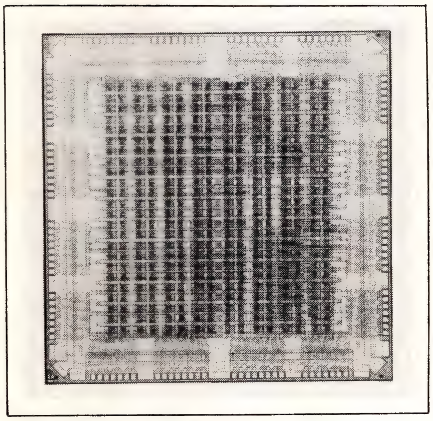
ENCRYPTION IC

- *Implements SEEK and RSA algorithms*
- *Provides encryption-key management*

The Model CY-1024 key-management processor is an IC that implements the SEEK and RSA key-encryption algorithms. Although intended primarily for encryption-key management, at lower speeds the device can provide secure data encryption. The IC can add, multiply, and exponentiate two integers modulo a third integer. The integers can be as long as 1028 bits. You can cascade as many as 16 of the µP-compatible devices to accommodate integers as long as 16,384 bits. This serial-I/O IC operates at a 20-MHz clock speed. The manufacturer also provides an evaluation board that you can insert in an IBM PC; the board demonstrates the SEEK and RSA algorithms, finds large prime numbers, and facilitates evaluation of the IC. CY-1024, $100 (OEM qty); the evaluation board with software, $1000.

Cylink, 920 W Fremont Ave, Sunnyvale, CA 94087. Phone (408) 735-5800.

Circle No 442



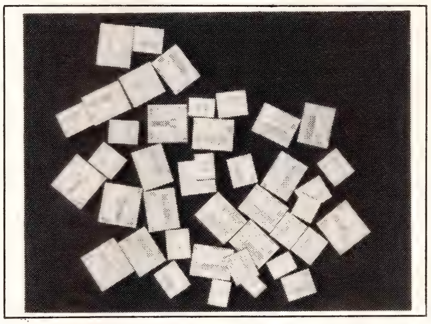
ECL GATE ARRAYS

- *Include 10KH ECL, 100K ECL, and TTL I/O buffers*
- *Offer 4580- and 6580-gate densities*

The first two products in the manufacturer's planned ECL-gate-array family, Models ET3000 and ET4500 offer equivalent gate densities of 4580 and 6580 gates, respectively. The basic gate used in both parts has propagation times of 220 psec (unloaded) and 500 psec (loaded). I/O propagation delays are 650 psec for each ECL output buffer and 5 nsec for each TTL I/O-buffer pair. Model ET3000 can have as many as 120 I/O lines, of which you can configure 72 as ECL output buffers; the ET4500 has 136 I/O lines, of which you can use 84 as ECL outputs. You can use either part as TTL gate arrays that operate from 5V, or as 10KH or 100K ECL arrays that work from −5.2 and −4.5V, respectively. For mixed TTL/ECL applications, the devices can operate from 5V and −4.5 or −5.2V. The ET3000 and ET4500 come in a 149-pin ceramic pin grid array (PGA) containing a heat sink; the ET4500 is also available in a 208-pin PGA. The devices dissipate 6 to 7W and 9 to 10W, respectively. ET3000, $228; ET4500 (in 149-pin PGA), $335 (100).

Fujitsu Microelectronics Inc, 3320 Scott Blvd, Santa Clara, CA 95054. Phone (408) 727-1700. TWX 910-338-0190.

Circle No 443



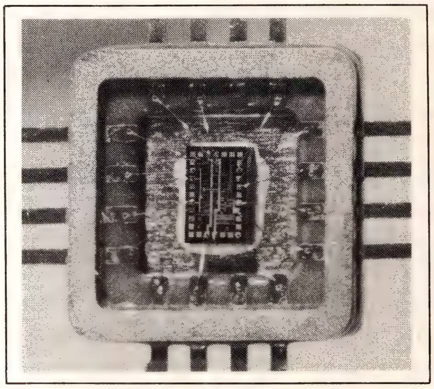
ANALOG-IC DICE

- *Suitable for use in hybrid circuits*
- *100% electrically probe-tested*

Five analog ICs now available in die form bring the manufacturer's complement of die products to 18. The five products include the OPA128JD low-bias-current (75 fA max at 25°C) operational amplifier; the INA110AD instrumentation amplifier; the INA105AD unity-gain differential amplifier; the XTR101AD 2-wire 4-to-20-mA transmitter, and the MPY534AD analog multiplier. The wafers and dice receive 100% inspection according to MIL-STD-883, Method 2010, Condition B. Dice receive an additional quality-control inspection to a 0.65% acceptance quality level. $2.80 to $17.50 (100).

Burr-Brown Corp, Box 11400, Tucson, AZ 85734. Phone (602) 746-1111. TWX 910-952-1111.

Circle No 444



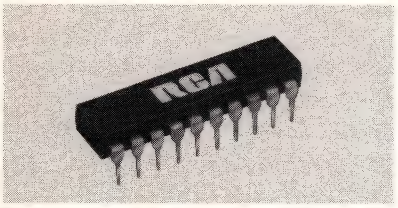
GaAs AMPLIFIER

- *Operates over a 2-GHz bandwidth*
- *Suitable for fiber-optic systems*

A member of the manufacturer's family of 1500 Series GaAs fiber-optic devices, the TIA1500 transimpedance amplifier is a monolithic IC that's suitable for use in analog or digital fiber-optic systems. It accepts input frequencies as high as 2 GHz from either a pin diode or an avalanche photodiode. An adjustable FET feedback network allows you to optimize the IC's receiver sensitivity and transimpedance gain in your application. The device draws 120 and 110 mA, respectively, from its 4 and −3.5V supplies. Its 500-MHz transimpedance is 1 kΩ; the maximum input power is 0 dBm; sensitivity at 1 GHz is −30 dBm; and the automatic-gain-control range is 10 dB. The amplifier is available in chip form or in a 46×72-mil ceramic package. $150.

Microwave Semiconductor Corp, 100 School House Rd, Somerset, NJ 08873. Phone (201) 563-6300. TLX 833473.

Circle No 445



OCTAL TRANSCEIVER

- *Provides 2-way asynchronous communication*
- *Compatible with bipolar logic*

You can effect 2-way asynchronous communication between data buses by using the CD54/74AC245 octal transceiver. The CMOS IC is pin, function, and spec compatible with such high-speed bipolar logic as FAST and advanced Schottky. The device embodies the manufacturer's ACL (advanced CMOS logic) process. According to the manufacturer, ACL ICs provide four times greater output drive than you can obtain from earlier HC and HCT units. The transceiver has 2-kV electrostatic-discharge resistance for the human-body model, 400V for the machine model. Two packaging options are available: the CD54AC245 comes in a 20-pin hermetic ceramic DIP and operates over −55 to +125°C; the CD74AC245 is housed in either a 20-pin plastic DIP (E suffix) or a surface-mount DIP (M suffix). Model CD74AC245E, $4.60 (100).

GE/RCA Solid State Div, Route 202, Somerville, NJ 08876. Phone local office.

INQUIRE DIRECT

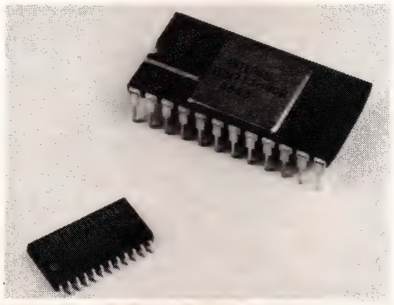
REGISTER-FILE IC

- *First ECL 4-port register file*
- *Simultaneously reads two words*

Designed for high-speed scratchpad memory, Model Am29434 is an ECL-compatible, 32-bit dual-access 4-port register file that simultaneously reads and writes two words in a single cycle. The device replaces ECL RAM, discrete logic, or gate-array implementations; it eliminates interchip timing delays and reduces the part count in 32-bit ECL systems. Featuring a 20-nsec access time, the IC accommodates a 50- to 60-nsec system cycle time, depending on the system's configuration. The unit's architecture provides two write and two read ports for data, and four 6-bit address ports. The 10K-compatible IC's organization is 64 words×8 bits. You can cascade the device horizontally or vertically. Housed in a 120-pin pin grid array, it costs $180 (100).

Advanced Micro Devices Inc, Box 3453, Sunnyvale, CA 94088. Phone (408) 732-2400.

Circle No 407

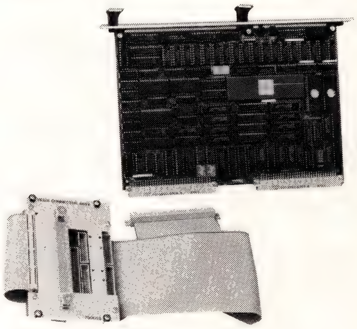


REAL-TIME CLOCK

- *Stable over the military temperature range*
- *Conforms to MIL-STD-883B, Rev C*

Claimed by its manufacturer to be the only real-time-clock (RTC) chip that's stable over the −55 to +125°C temperature range, Model ICM7170 is fully compliant with MIL-STD-883B, Rev C. Long-term stability of the oscillation frequency, set by the crystal and not the RTC IC itself, is 2 ppm/month. The device's features include battery-backup circuitry; options for three crystal frequencies (32 kHz and 1.084 and 2.097 MHz); 2-μA typ standby current; a leap-year-compensating 128-year calendar; and a 300-nsec register access time max. The IC works with multiplexed and directly accessed buses, and contains internal latches that prevent clock rollover during a read cycle. For the MIL-STD-883 version in a

The Ultimate VME ESDI Controller



Would Have...
☐ Zero latency reads *and* writes
☐ 250 KB cache
☐ Dynamically configurable caching parameters
☐ Intelligent look-ahead caching
☐ Support for four 24 Mbit/sec. drives
☐ 32 and 16-bit DMA transfers
☐ 32 and 24-bit addressing
☐ Multiple-copy disk reads
☐ Contiguous or scatter transfers
☐ 48-bit ECC
☐ On-board 12 MHz MC68000 processor
☐ Companion SMD controller with identical software interface
☐ A proven field record of reliability and performance

The VESDI-32 only from

DUAL

Dual Systems Corporation
2530 San Pablo Avenue
Berkeley, CA 94702
(415) 549-3854
FAX: (415) 394-5256
TLX: 230199 SWIFT

CIRCLE NO 158

24-pin ceramic DIP, $27.90; devices in plastic DIP or SO package, $7.50 (100).

GE Intersil Semiconductor, 10600 Ridgeview Court, Cupertino, CA 95014. Phone (800) 443-7364; in NY, (800) 243-7364. TWX 910-338-0171.

Circle No 408

SERIAL CONTROLLER

- *First CMOS serial communications controller*
- *Equivalent to industry-standard μPD7201A*

Claimed by its manufacturer to be the industry's first CMOS-processed, complete serial communications controller, Model μPD72001 is equivalent to the industry-standard μPD7201A controller. The device contains baud-rate generators, a crystal oscillator, and a digital phase-lock loop. The chip has two independent, full-duplex channels, either of which you can configure to transmit or receive (or both) any of three protocols at synchronous speeds as high as 1.6 MHz. Protocols include both character-oriented (Bisync) and bit-oriented (SDLC/HDLC). Available in both a 40-pin plastic DIP and a 44-pin PLCC. Less than $25 (1000).

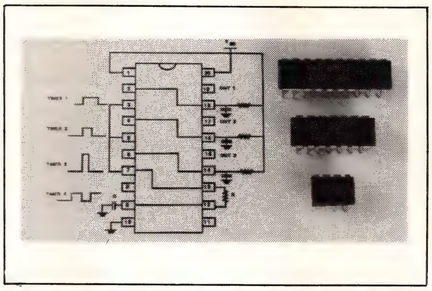
NEC Electronics Inc, 401 Ellis St, Mountain View, CA 94039. Phone (800) 632-3531; in CA, (800) 632-3532. TWX 910-379-6985.

Circle No 409

QUAD CMOS TIMERS

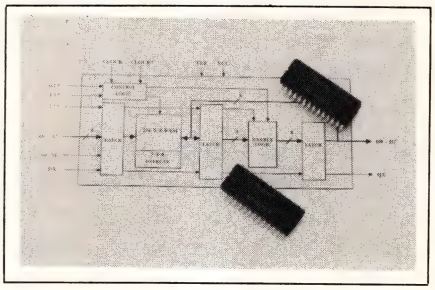
- *Single, dual, and quad devices*
- *Specs 10-nsec rise and fall times*

Able to trigger from 50-nsec pulses, this family of CMOS timers embraces two sets of single, dual, and quad devices. All units spec rise and fall times of 10 nsec. Single, dual, and quad models ALD1502, -2502, and -4501 operate from 2 to 12V supplies; models ALD1504, -2504, and -4503 can use 1 to 12V supplies. Quiescent-current specs range from 70 μA max for a single device operating from a 1V supply, to 270 μA at 5V for the quad units. The singles' and duals' current-sinking capability is 80 mA; the quad devices can sink 40 mA. The singles and duals are pin compatible with NE555 and NE556 bipolar units; the quads have a 20-pin configuration that allows for four independent timing thresholds. The single, dual, and quad timers are available in 8-, 14-, and 20-pin (respectively) plastic and ceramic DIPs. $0.81 to $3.41 (100).



Advanced Linear Devices Inc, 1030 W Maude Ave, Suite 501, Sunnyvale, CA 94086. Phone (408) 720-8737. TWX 510-100-6588.

Circle No 410



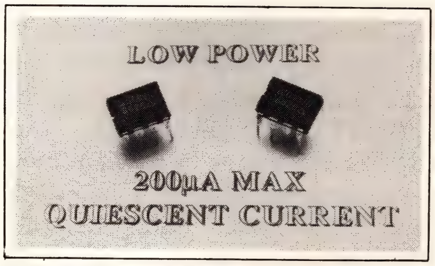
STATIC RAMs

- *Suitable for high-resolution graphics*
- *Use pipelined architecture*

These four pipelined static RAMs find use as color-palette memories in graphics systems having resolution as high as 2000×2000 pixels. Models Bt401, -402, -403, and -404 are all 256×8-bit static RAMs that spec 4-nsec cycle times. You can cascade any of the RAMs to build large color palettes. Each chip has 3-state outputs. Models Bt401 and -402 have 3×8-bit Sidecar RAMs that provide cursor support and overlay capabilities. The Bt401 is compatible with 10K ECL circuitry, the Bt402 with 100K ECL circuitry. Models Bt403 and -404 are equivalent to the Bt401 and -402, respectively, but do not contain the 3×8-bit Sidecar RAMs. All the RAMs accommodate synchronous and asynchronous reading and asynchronous writing. Housed in a 28-pin ceramic DIP, Models Bt401 and -402 cost $39 (100). In 24-pin ceramic DIPs, Models Bt403 and -404 cost $36. 100K- and 10K-compatible devices will be available in production quantities in the first and second quarters of this year, respectively. Samples of all units are available now.

Brooktree Corp, 9950 Barnes Canyon Rd, San Diego, CA 92121. Phone (619) 452-7580. TLX 383596.

Circle No 411



FET OP AMPS

- *Available in single and dual units*
- *Minimize power/performance compromises*

Models AD548 and -648 single and dual (respectively) FET-input operational amplifiers spec a 200-μA max quiescent current and typically provide a 1-MHz unity-gain bandwidth and a 1.8V/μsec slew rate. Other specs for the AD548 single op amp include a 10-pA max bias current and a 5-μV/°C max input-offset drift. Additional specifications include a 250-μV offset voltage max, 86-dB min common-mode rejection, 2-μV p-p typ input noise, and 300,000V/V open-loop gain. The amplifiers are available in 8-pin plastic or ceramic DIPs or in TO-99 metal

digelec PROM & Logic Programmers

1-2-3-4 AT A TIME MAKES PROGRAMMING AS EASY AS 1-2-3-4

MODEL 825
SET PROGRAMMER

- **PROGRAMS:**
  - ☐ Up to 4 devices simultaneously with the **same** or **different** data.
  - ☐ **16K to 1024K** Bit **E²/EPROMs** from all manufacturers (more than 220 devices)
  - ☐ **Intel (87 xx)** and **Motorola (68701/68705,** 28- and 40-pin) **single-chip micros**
- **FEATURES:**
  - ☐ **8, 16, 32** bit or **GANG** operations
  - ☐ **64K Byte** standard **RAM** (expandable to **256K Byte)**
  - ☐ **Built-in UV eraser**
  - ☐ Plug-in **SOFTPACK** cassette for do-it-yourself software updates
  - ☐ Programming **Verification at 3 VCCs**
  - ☐ Fully **programmable VCC & VPP** for future programming needs
  - ☐ **Detects Device type** (signature)
  - ☐ **Detects misplaced** device
- **SUPPORTS:**
  - ☐ 5 different programming algorithms, including **Intel Intelligent** and **Quick-Pulse, AMD Flashrite**
- **OFFERS OPTIONALLY:**
  - ☐ **SOFTLINK** remote control software for **IBM PC/XT/AT**
  - ☐ **PLCC** module
  - ☐ Adapter for **1 M bit EPROMs** and **Motorola micros**

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Tel: (201) 493-2420
Fax: (201) 493-2426
Tlx: (230)754098

EUROPE: DIGELEC AG,
Dorflistrasse 14,
CH-8057 Zurich, Switzerland
Tel: 01-312 46 22
Fax: 01-312 46 66,
Tlx: 823795 dige ch

CIRCLE NO 173

cans. They're also available for three temperature ranges and with MIL screening. Prices for the AD548 and -648 range from $0.75 to $9.50 and from $1.25 to $12.95 (100), respectively.

Analog Devices, Literature Center, 70 Shawmut Rd, Canton, MA 02021. Phone (617) 935-5565. TWX 710-394-6577.

Circle No 412

HIGH-SPEED OP AMP

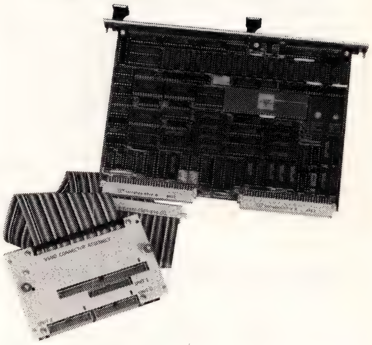
- *Can drive 50Ω loads*
- *Fully specifies all ac parameters*

A drop-in replacement for industry-standard 3554 amplifiers, the Model BB3554 high-speed op amp guarantees minimum and maximum values for all important ac parameters. All devices receive 150°C burn-in testing. The op amp's ac specs include a 1000V/V min open-loop gain at 1 MHz, a 16-MHz min full-power bandwidth, a 1000V/μsec min slew rate, and a 70-MHz min small-signal bandwidth. The settling time to within a ±0.01% error band is 250 nsec max; to ±1%, 60 nsec max. The data sheet specifies all ac parameters for source and load resistances of 50Ω; the amplifier provides ±10V min output swing into a 100Ω load. The device's dc parameters include a 1-mV max offset voltage, 50-pA max input-bias current, and 106-dB min open-loop gain. Housed in a TO-3 can, the amplifier is available in −25 to +85°C and −55 to +125°C versions. $47.70 to $66.30 (100).

Maxim Integrated Products, 510 N Pastoria Ave, Sunnyvale, CA 94086. Phone (408) 737-7600.

Circle No 413

The Ultimate VME SMD Controller



Would Have...

- ☐ Zero latency reads *and* writes
- ☐ 250 KB cache
- ☐ Dynamically configurable caching parameters
- ☐ Intelligent look-ahead caching
- ☐ Support for three 3 MByte/sec. drives
- ☐ 32 and 16-bit DMA transfers
- ☐ 32 and 24-bit addressing
- ☐ Multiple-copy disk reads
- ☐ Contiguous or scatter transfers
- ☐ 48-bit ECC
- ☐ On-board 12 MHz MC68000 processor
- ☐ Companion ESDI controller with identical software interface
- ☐ A proven field record of reliability and performance

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Dual Systems Corporation
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Berkeley, CA 94702
(415) 549-3854
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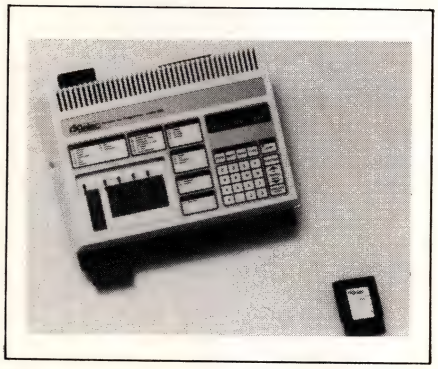
TLX: 230199 SWIFT

CIRCLE NO 159

NEW PRODUCTS

TEST & MEASUREMENT INSTRUMENTS



EPROM PROGRAMMER

- *Handles single-chip μPs*
- *Programs EEPROMs grouped into 8-, 16-, or 32-bit word widths*

The EP-825 portable set programmer handles all current EPROMs and EEPROMs that have capacities as high as 1M bit. The unit also works with Intel's 8-bit single-chip μPs. The device comes with one 40-pin socket for μPs and four 28-pin sockets for EPROMs and EEPROMs. For 16- and 32-bit applications, you can program four 8-bit words, two 16-bit words, or one 32-bit word at a time. The programmer has 256k bytes of internal RAM and a built-in, 6-chip UV eraser. $1795.

Digelec Inc, 1602 Lawrence Ave, Ocean, NJ 07712. Phone (201) 493-2420.

Circle No 414

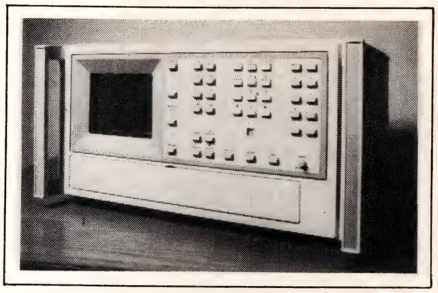
THERMOMETERS

- *Switch-selectable Fahrenheit or Celsius scales*
- *Variety of thermocouple models*

Budget Series digital thermometers accommodate a range of probes for measuring surface, liquid, and air temperatures. The thermometers are available with type K, J, and T thermocouples. You can choose high-resolution (0.1° sensitivity) or switch-selectable °F and °C scales. One model covers the −120 to +2000°F temperature range. $99.

Tegam Inc, 7230 N Ridge Rd, Madison, OH 44057. Phone (216) 428-7505. TLX 205188.

Circle No 415



WAVEFORM ANALYZER

- *Fully programmable over the IEEE-488 bus*
- *Has a 1-GHz bandwidth for repetitive signals*

The Model 3000 dual-channel waveform analyzer has a 1-GHz bandwidth for repetitive signals. It digitizes signals to 12-bit resolution. The instrument has a trigger bandwidth of 200 MHz with 5-psec typ trigger jitter. Its built-in functions perform such measurements as pulse width, rise and fall time, period, and delay between the signals on the two channels. The unit has a standard IEEE-488 interface. $19,000. Delivery, 45 to 60 days ARO.

Datron EHE Instruments, 4125 SW Martin Hwy, Stuart, FL 33497. Phone (305) 283-0935.

Circle No 416

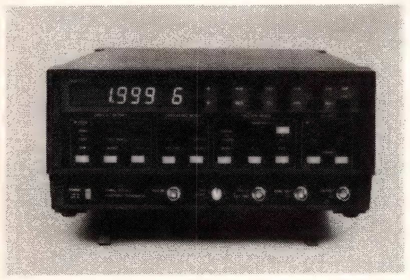
GANG PROGRAMMER

- *Handles 16- and 32-bit word lengths*
- *Works in series with CRT terminal*

The PP42 gang programmer has eight sockets for 24- and 28-pin EPROMs and EEPROMs. You can program 16-bit words across two devices or 32-bit words across four without shuffling any data in the programmer's 4M-bit memory. The programmer can handle multiple sets—that is, it can program 16-bit words into four pairs of 8-bit devices. The programmer works with most process technologies and executes common fast-programming algorithms. It has two RS-232C ports. Optional software allows you to control the device from an IBM PC. The unit weighs 7 lbs and measures 8½×12¼×3 in. PP42 with a 512k-bit RAM, $1995.

Stag Microsystems Inc, 528-5 Weddell Dr, Sunnyvale, CA 94089. Phone (408) 745-1991. TLX 910-339-9607.

Circle No 417



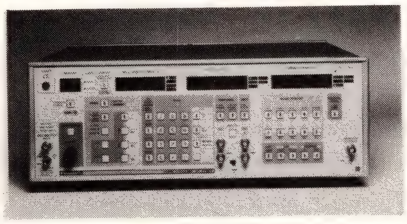
COMBO GENERATOR

- *Parameters fully programmable over IEEE-488 bus*
- *Fast low-frequency measurements with reciprocal counter*

The 6201A pulse/function generator combines three programmable instruments: a pulse generator, a function generator, and a 20-MHz counter. The instrument provides sine, triangle, and square waves as well as pulses with variable amplitude, symmetry, and offset over a frequency range of 2 mHz to 20 MHz. Its output amplitude ranges from 1 mV to 30V p-p (15V into 50Ω). The unit's nonvolatile memory stores 10 front-panel settings. The instrument is fully programmable over the IEEE-488 bus. Model 6201A, $3375; rack-mount kit, $175.

Ballantine Laboratories Inc, Box 97, Boonton, NJ 07005. Phone (800) 323-3234; in NJ, (201) 335-0900.

Circle No 418



AUDIO ANALYZER

- *Instrument measures total harmonic distortion digitally*
- *Computes ratio of signal levels between two channels*

The VP-7722P audio analyzer has a 10-Hz to 110-kHz frequency range. This dual-channel instrument measures distortion to 0.001%, intermodulation distortion, signal-to-noise ratio, and a signal's frequency and level. Further, the analyzer measures total harmonic distortion (THD) and finds the ratio of the signal levels at its two inputs over an 80-dB dynamic range. The instrument is fully programmable over the IEEE-488 bus and can store 100 setups internally. $6380. Delivery, stock to six weeks ARO.

Panasonic Industrial Co, 1 Panasonic Way, Secaucus, NJ 07094. Phone (201) 348-7183.

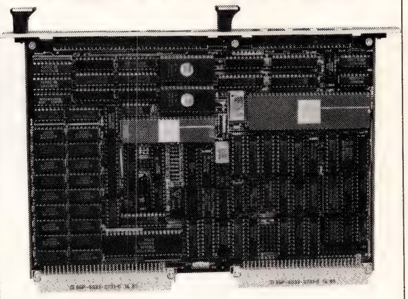
Circle No 419

SPECTRUM ANALYZER

- *Weighs less than 20 lbs*
- *Specs a frequency accuracy of ±10 kHz at 1 GHz*

The TEK 2710 spectrum analyzer covers the 10-kHz to 1.8-GHz frequency range. Weighing less than 20 lbs, the analyzer provides a frequency accuracy of one part in 10^5 (or ±10 kHz at 1 GHz). An optional model provides an accuracy of ±500 Hz at 1 GHz. The instrument's sensitivity is −117 dBm at a 3-kHz resolution bandwidth. If you switch on the built-in preamplifier, the sensitivity spec becomes −129 dBm. The analyzer can store four traces, and its display provides readouts of cursor positions and differences. The standard resolution is 3 kHz. The manufacturer claims that the optional 300-Hz resolution adds 10 dB of sensitivity. An optional built-in frequency counter is also available. The instrument's on-screen dynamic range is 80 dB. You can select reference levels from among dBm, dBmV, dBV, dBμV, dBμW,

The Ultimate VME SCSI/ ST-506/ SA-450 Controller



Would Have...
☐ Support for 8 SCSI devices, 2 ST-506 hard disks and 2 SA-450 DSDD floppy disks on a single card
☐ On-board MC68000 processor with 512 KB RAM
☐ Signetics 68454 ST-506/SA-450 controller
☐ NCR SCSI controller with 16-bit DMA data path; supports 1.5 MByte/sec. async. transfer rate
☐ Dual-ported registers and memory accessible by both the VMEbus and local 68000
☐ EXTENDED, STANDARD and SHORT VME addressing
☐ On-board VME interrupt handler and requestor
☐ Mailbox interrupt communication port
☐ Full software support via powerful real-time executive
☐ Drivers for many popular devices supported in *firmware*

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Berkeley, CA 94702
(415) 549-3854
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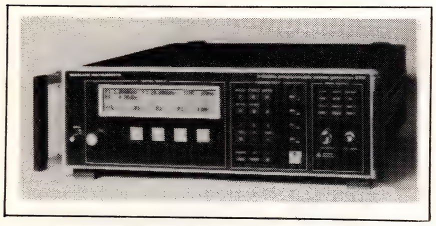
TLX: 230199 SWIFT

CIRCLE NO 160

and dBμV/m. The instrument has 50 and 75Ω inputs. $8250. Delivery, 10 weeks ARO.

Tektronix Inc, Box 15149, Portland, OR 97215. Phone (800) 835-7732; in OR, (503) 235-7315.

Circle No 420



SWEEP GENERATOR

- *Covers the 2- to 20-GHz frequency range*
- *Lets you set five markers in one sweep*

The 6310 sweep generator covers the 2- to 20-GHz frequency range. Its spurious harmonics spec −40 dBc, and its subharmonics measure −60 dBc. When leveled, the power setting has an accuracy of 0.2 dB typ. The instrument is fully programmable over the IEEE-488 bus. It lets you set five markers. The unit's display shows the status of the markers and the difference between a marker's frequency and the reference frequency. The generator's frequency accuracy is 3 MHz typ. The unit stores 20 setups. $21,950. Delivery, 60 to 90 days ARO.

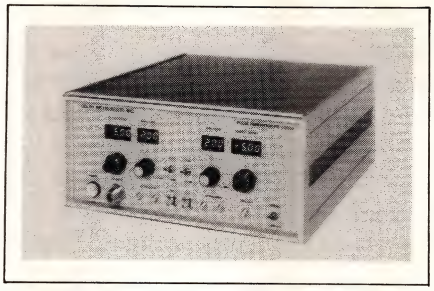
Marconi Instruments, 3 Pearl Ct, Allendale, NJ 07401. Phone (201) 934-9050.

Circle No 421

PULSE GENERATORS

- *Dual, multigigahertz outputs suit GaAs logic and laser diodes*
- *Attenuators don't limit the dc-offset range*

The PG 5000A dual-channel pulse generator delivers 2V at repetition rates as high as 5 GHz; the PG 3000A specs 5V at 3 GHz. The PG 5000A's rise time measures 45 psec (10 to 90%) at 4 GHz. Each channel has an independent attenuator that ranges from 0 to −20 dB in 1-dB steps. The generators' attenuators don't affect the dc-offset range. According to the manufacturer, the instruments' duty cycle is nearly 50% at all repetition rates. You control the rise and fall times by reducing the sinusoidal input-drive level. Both generators are available in differential-output and equal-phase-output models as well as in single-output (4 and 10V) high-power models. PG 5000A, $17,500; PG 3000A, $19,500. The high-power versions, PG 5000A-4V and PG 3000A-10V, cost $22,500 and $25,000, respectively.



Colby Instruments Inc, 1810 14th St, Santa Monica, CA 90404. Phone (213) 450-0261.

Circle No 422

SYSTEMS DMM

- *Operates on the IEEE-488 bus at 100 readings/sec*
- *Provides stand-alone control of signal-scanning units*

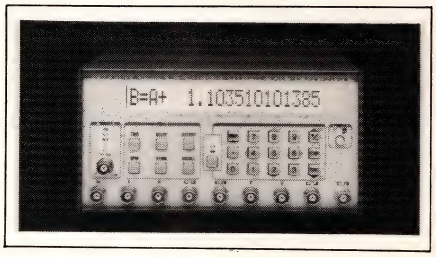
The PM 2535 system multimeter can control the company's System 21 signal-switching and I/O units, allowing you to implement a data-acquisition system with as many as twenty 2-pole measuring channels without the need for a separate system controller. Alternatively, you can control the DMM and the System 21 units via the DMM's built-in IEEE-488 interface. The PM 2535's dc-voltage measurement function has a 90-day accuracy of 0.005%; it makes fully guarded measurements with a resolution of 100 nV. The DMM also measures true-rms ac volts at frequencies as high as 100 kHz, current to 3A, resistance between 1 mΩ and 300 MΩ, and temperature. You can trade measurement speed for resolution by selecting scale lengths between 3½ and 6½ digits. At a 3½-digit resolution, the PM 2535 can send measurements to the IEEE-488 bus at speeds to 100 readings/sec. Alternatively, you can capture as many as 999 readings in the DMM's internal memory at read rates as high as 150 readings/sec before transmitting them over the IEEE-488 bus. Other features include computation capabilities, limit checking, and storage and recall of maximum and minimum measurement values. $1395.

Philips, Industrial & Electroacoustic Systems Div, Box 523, 5600 AM Eindhoven, The Netherlands. Phone (040) 757005. TLX 51573.

Circle No 423

Philips Test and Measuring Instruments Inc, 85 McKee Dr, Mahwah, NJ 07430. Phone (201) 529-3800.

Circle No 424



PULSE GENERATOR

- *Generates 5-nsec to 100-sec pulses*
- *Pulses have a rise time as fast as 2.5 nsec*

The DG535 is a dual-channel pulse generator that generates pulses whose widths range from 5 nsec to 1000 sec. The instrument also functions as a 4-channel digital-delay generator. You can select output delays from 1 to 1000 sec with 5-psec resolution. The pulse generator has TTL, ECL, and NIM (nuclear instrument module) output levels. Internal trigger rates range from

This meter calibrator has to be *precise, stable & versatile…*

…but nobody said it has to be expensive

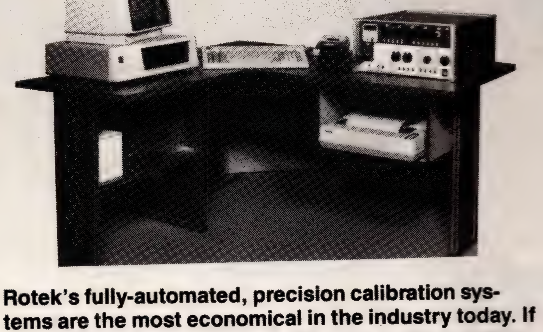
In years past, a calibration standard worthy of the name usually cost an arm and a leg. Many, in fact, still do.

But Rotek's 3900A Series of calibration sources has put high-precision meter and instrumentation calibration within reach of virtually every metrology lab.

Each of these superb, multifunction calibrators provide AC/DC voltages, AC/DC currents and a precision resistance source for checking and calibrating a wide variety of digital and analog meters and instruments. Although prices start at only $4175, the accuracy, stability and frequency specifications of the series compare favorably with instruments costing two and three times as much.

The 3900A Series includes seven instruments, ranging from the 3910A basic calibrator to the sophisticated Model 3980A, providing V/I/R values accurate to 50 ppm and frequencies to 50 kHz. Optional current amplifiers and IEEE interface are available for use with all models.

The unique advantage of the series is that *you can buy exactly the capabilities you need, without paying more or getting less than your requirements call for.* Write or call us today for prices and details on these and other Rotek calibration systems.



Rotek's fully-automated, precision calibration systems are the most economical in the industry today. If you calibrate large numbers of instruments, a system like this could save you time and money.

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INSTRUMENT CORP.

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BOX 504
WALTHAM, MA 02154
(617) 899-4611

CIRCLE NO 161

0.001 Hz to 1 MHz. You can vary the outputs' duty cycle from 0.003 to 100%. An IEEE-488 interface is standard. DG535, $2995; 1-ppm TCXO timebase option, $350.

Stanford Research Systems Inc, 460 California Ave, Palo Alto, CA 94306. Phone (415) 324-3790. TLX 706891.

Circle No 425

16-CHANNEL FILTER

- *Each channel is tunable over a 0.1-Hz to 100-kHz range*
- *Six different 8-pole filter plug-ins are available*

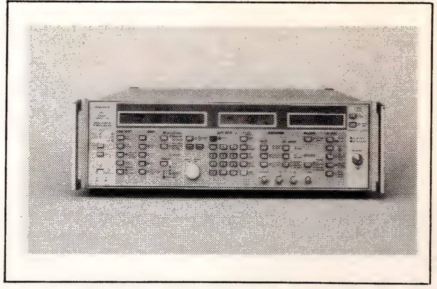
The 9016 programmable-filter mainframe holds as many as 16 filter plug-ins. The filters are tunable over a frequency range of 0.1 Hz to 100 kHz, and they can store 8 preset configurations. Each filter plug-in has its own BNC connectors at the instrument's rear. The mainframe's controller card has battery backup. An IEEE-488 interface is optional. Six 8-pole filter plug-ins are available for the instrument: Butterworth lowpass, 6-zero Cauer elliptic, Bessel lowpass, 6-zero constant-delay lowpass, Butterworth highpass, and 6-zero Cauer elliptic highpass. Model 9016 mainframe, $3500; IEEE-488 version, $4000; filter plug-ins, from $800 to $950. Delivery, eight weeks ARO.

Frequency Devices Inc, 25 Locust St, Haverhill, MA 01830. Phone (617) 374-0761. TWX 710-347-0314.

Circle No 426

SWEEP GENERATORS

- *Synthesizers also perform analog sweep*
- *Each unit includes a pulse generator*



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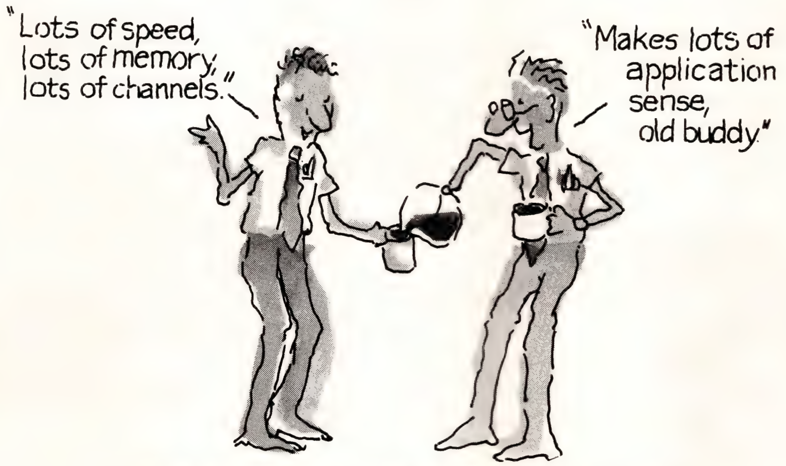
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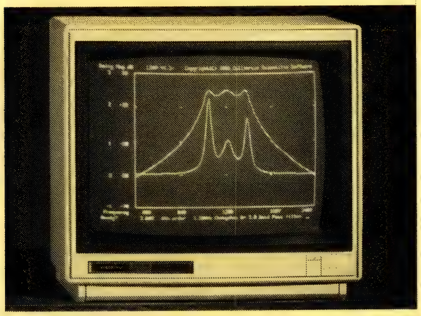

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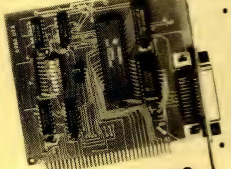

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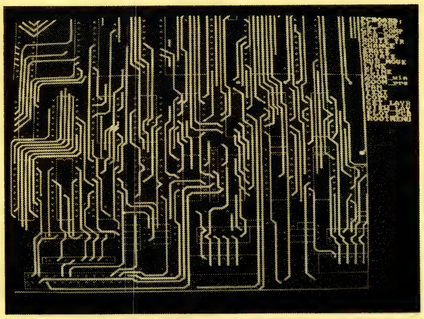

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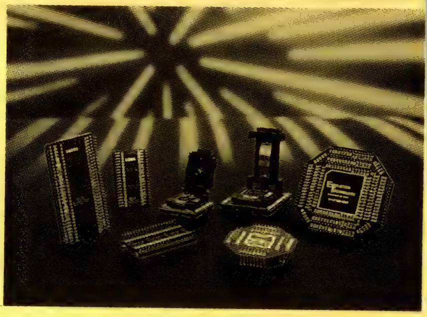

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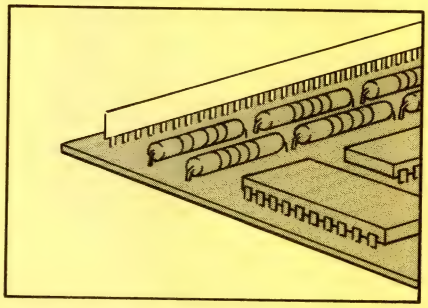

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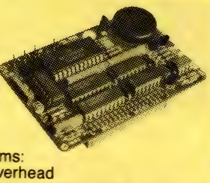

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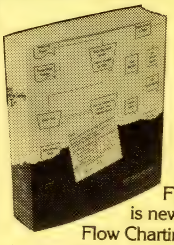

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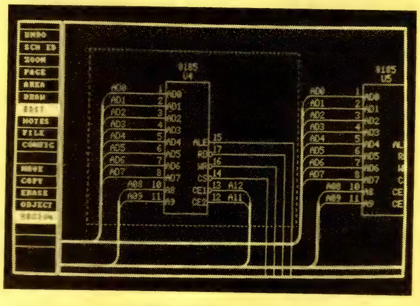

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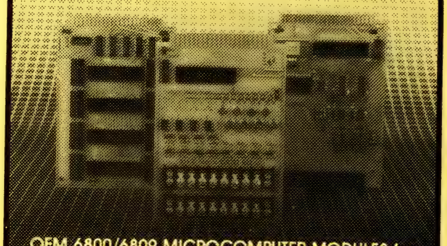

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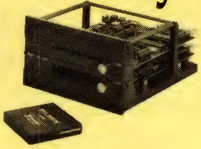

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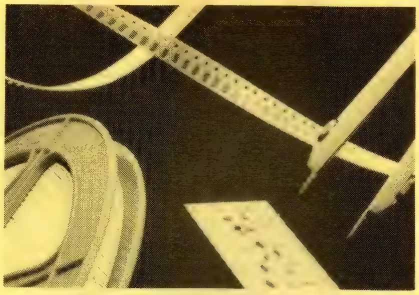

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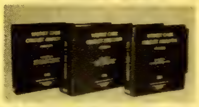

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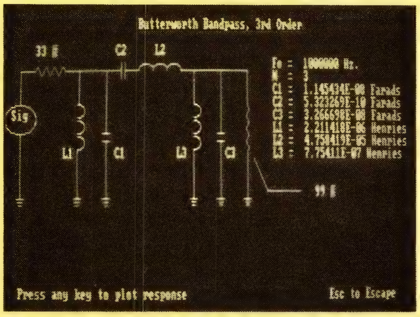

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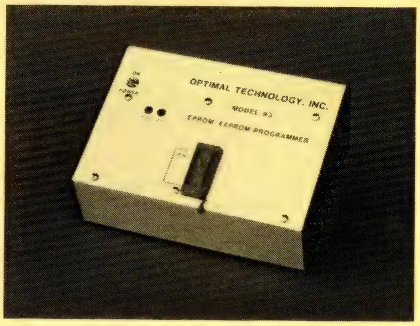

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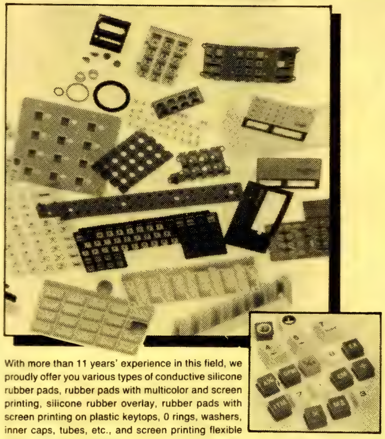

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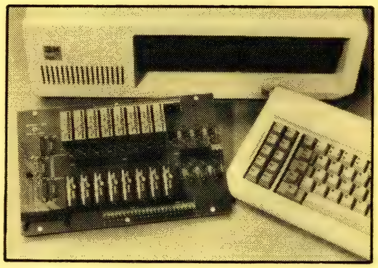

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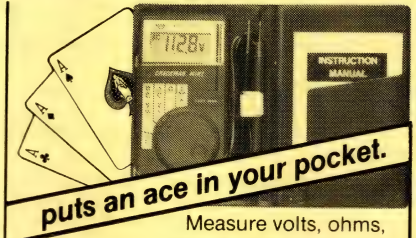

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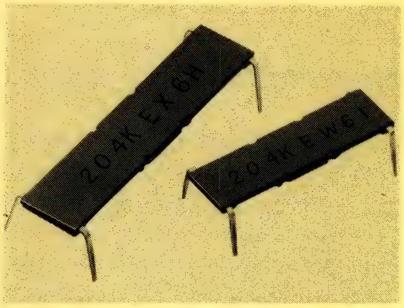

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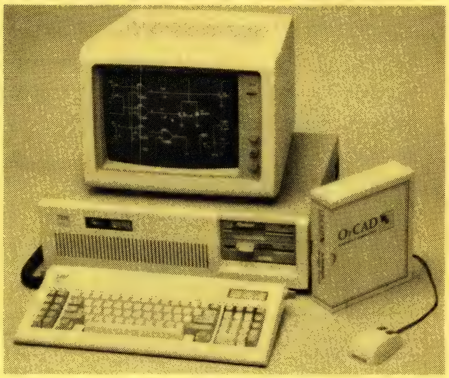

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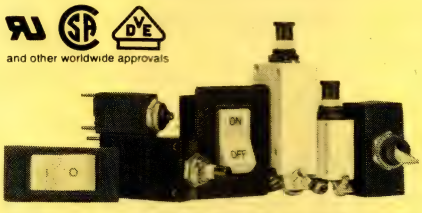

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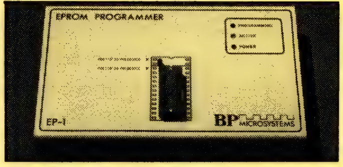

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Guide documents Silicon Valley companies

The fifth edition of *Rich's High-Tech Business Guide to Silicon Valley* provides detailed information about 2969 Northern California companies. The book covers businesses located between Bakersfield and Napa County and includes 921 vendors not previously listed. It gives names of key executives, addresses, phone numbers, numbers of employees, maps of company locations, year established, and descriptions of products. The guide costs $98.50 plus $3.50 for shipping (California residents, add $6.90 sales tax). It's also available on disk for $425.

Business Directories Inc, 101 First St, Suite 426, Los Altos, CA 94022.

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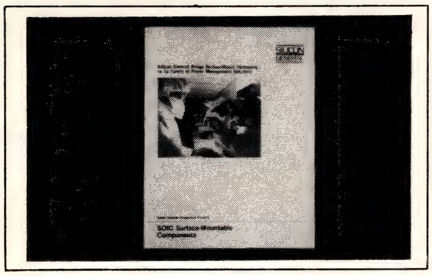


Brochure addresses surface-mount ICs

This 4-pg brochure highlights the manufacturer's line of small-outline surface-mount ICs, particularly its PWM products. The pamphlet includes thermal characteristics, package dimensions, and packaging options, and it briefly discusses the benefits of surface-mount technology.

Silicon General, 11861 Western Ave, Garden Grove, CA 92641.

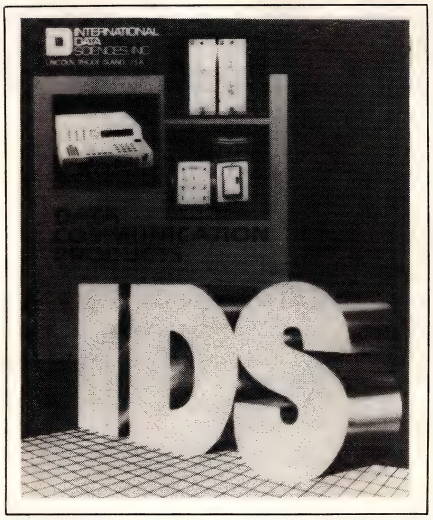
Circle No 429

Catalog features data-communications products

This 24-pg catalog highlights the vendor's data-communications products, including handheld test sets, data traps, datacomm testers, test sets and printers, modems, data switches, and modular switching devices. The catalog is 3-hole punched for loose-leaf filing.

International Data Sciences Inc, 7 Wellington Rd, Lincoln, RI 02865.

Circle No 430



All about attenuators

This 2-pg data sheet describes the company's In-A-Cable subminiature attenuators, which come in semirigid cable assemblies. The bulletin presents three tables. One table lists general technical data: SWR, power-dissipation ratings, temperature and power sensitivity, peak voltage characteristics, dimensions, and weight. Another lists materials and specs for all attenuator parts. The third table gives mechanical and environmental characteristics, including pressure, corrosion resistance, shock, moisture, and vibration. In addition, graphs plot performance curves for SWR vs frequency and for power derating under various temperature conditions.

Micro-Coax Components Inc, Collegeville, PA 19426.

Circle No 431

Source of data on the microcomputer industry

The Personal Computer—An Industry Source Book includes over 10,000 company profiles and lists more than 22,000 executives directly involved in the microcomputer industry. Containing more than 1200 pages, the loose-leaf-bound book breaks the microcomputer sector into 16 component parts and arranges company entries alphabetically within each particular area of manufacturing emphasis. Each company listing includes sales volume, year begun, number of employees, type of entity, key contacts, machine specialization, industry specialization, geographic coverage, channels of distribution, and product-line descriptions. In addition, this year's edition of the source book includes a section on the top 5000 computer dealers in the US. $495.

The Personal Computer—An Industry Source Book, Box 3249, Walnut Creek, CA 94598.

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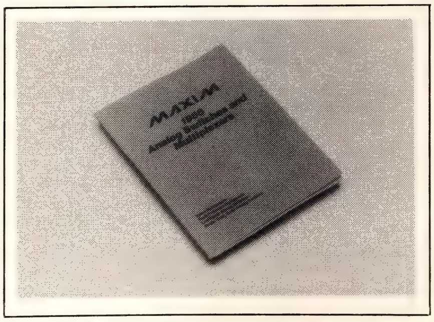

Switches, muxes cataloged

This manufacturer's 1986 catalog contains data sheets and applications information on 50 new products, including an entire line of CMOS analog switches and analog multiplexers. The 82-pg book also documents some product advances, including the improvements in the multiplexers' overvoltage fault protection that continue to protect input and output signal sources after the removal of power; and reduced power consumption and elimination of extra logic supplies on virtually all second-source analog switch products.

Maxim Integrated Products, 530 N Pastoria Ave, Sunnyvale, CA 94086.

Circle No 433

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How do we make it so simple? By enabling you to connect Tokin's MCT Series to any personal computer with a standard RS232C interface, a simple operation that also expands your PC applications.

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Communication format	Start bit 1 Data bit 8 Parity (even) 1 Stop bit 1	
Card driving system	Motorized	Manual
Performance	Read/write	Read only

Applicable Magnetic Card

Units		Card Standard
MCI-111	MCS-131 (E)	ISO, track 2
MCI-112	MCS-132 (E)	ISO, track 1
MCI-113	MCS-133 (E)	ISO, track 3
	MCS-135 (E)	ISO, track 1 and 2
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24 × 61 × 65mm	27 × 29.5 × 100mm (32.5 × 32 × 100)	

*(E): With cover

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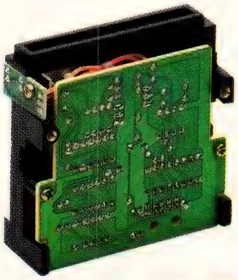
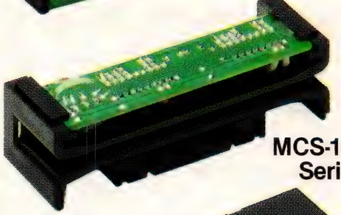


MCI-110 Series



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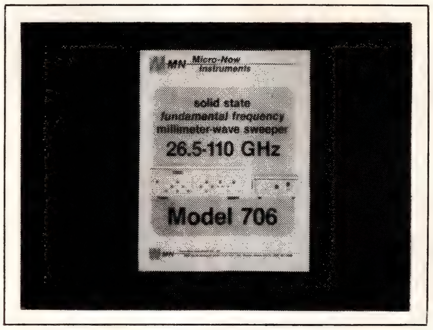
CIRCLE NO 163

Brochure aids in selecting surface-mount packages

This brochure describes the different package sizes available for the company's CMOS special-function devices, as well as the ICs' capabilities. The products covered include A/D and D/A converters, PLL/frequency synthesizers, decoders, display drivers, smoke detectors, remote-control devices, op amps, and comparators. The brochure describes PLCC and small-outline package structures and advantages. Request *BR503.*

Motorola Inc, Literature Distribution Ctr, Box 20912, Phoenix, AZ 85036.

Circle No 434



Brochure details sweeper

This brochure describes in detail Model 706, a solid-state millimeter-wave sweeper with a 26.5- to 110-GHz range. In addition to discussing the sweeper's capabilities and performance, the pamphlet mentions the modulation and leveling options. Photographs and charts supplement the text.

Micro-Now Instrument Co Inc, Box 1488, Skokie, IL 60076.

Circle No 435

Documents on ASICs

These three pieces of literature provide an overview of the company's ASIC offerings. *The ASIC Continuum* gives a synopsis of available ASIC products, ranging from programmable logic devices to gate arrays to cell-based custom ICs. *ASIC Design: A Continuum of Alternatives* describes the various design-interface and design-tool options, including workstation libraries and personal-computer-based systems. The *2-Micron Gate Array Databook* contains detailed design, applications, and data-sheet information for the manufacturer's line of CMOS gate arrays.

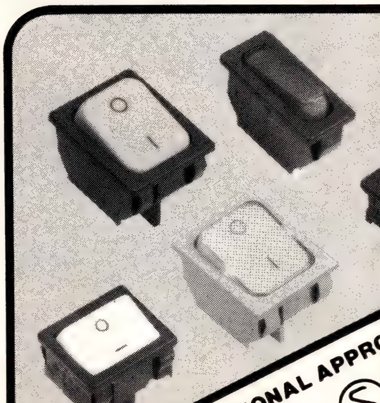
Gould Inc, Semiconductor Div, 3800 Homestead Rd, Santa Clara, CA 95051.

Circle No 436

Short-form catalog includes data on VLSI products

This 8-pg catalog features the company's analog and digital VLSI products such as A/D and D/A converters, multipliers, multiplier/accumulators, memory/storage products, and special-function products.

MARQUARDT



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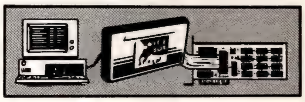

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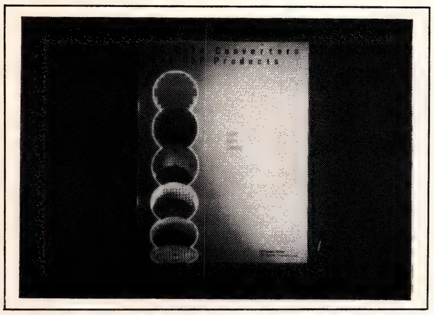

The catalog also includes a listing of packaging styles, with photos to go along with the key packages.

TRW Electronic Components Group, LSI Products Div, Box 2472, La Jolla, CA 92038.

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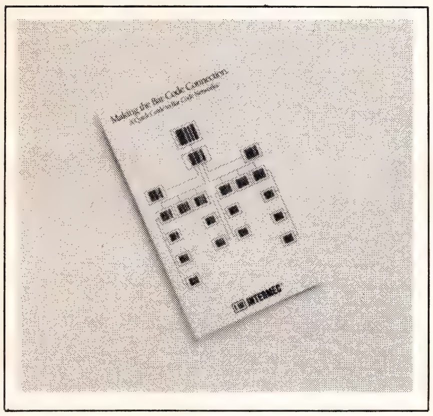

Tutorial on bar codes

Making the Bar Code Connection is a tutorial on bar-code data-collection networks. It explains three types of networks: on-line, fully integrated; stand-alone; and hybrid. It also discusses the advantages and disadvantages of each. Each section diagrams typical network configurations using components that constitute the company's Crossbar data-collection network (eg, readers, scanners, printers).

Intermec Corp, Box 360602, Lynnwood, WA 98046.

Circle No 438

Microcircuits described

This 12-pg brochure covers the manufacturer's custom-design capabilities and line of hybrid microcircuits, including high-speed digital circuits, power hybrids, microwave and analog microcircuits, space hybrids, and advanced modules. It also discusses the vendor's packaging technology and computer-aided design and manufacturing capabilities in terms of the microcircuits featured.

Hughes Aircraft Co, Box H, Newbury Beach, CA 92658.

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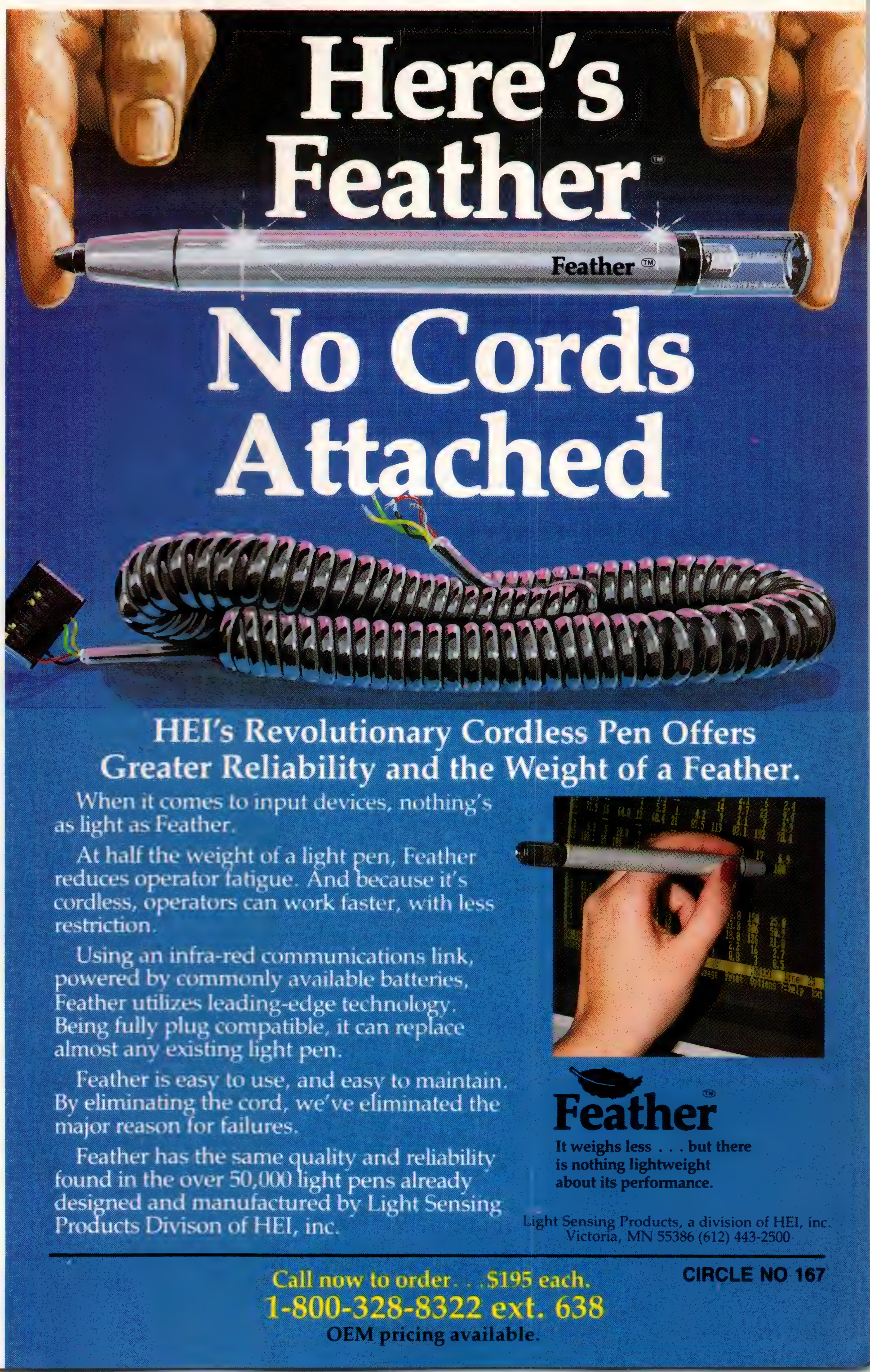

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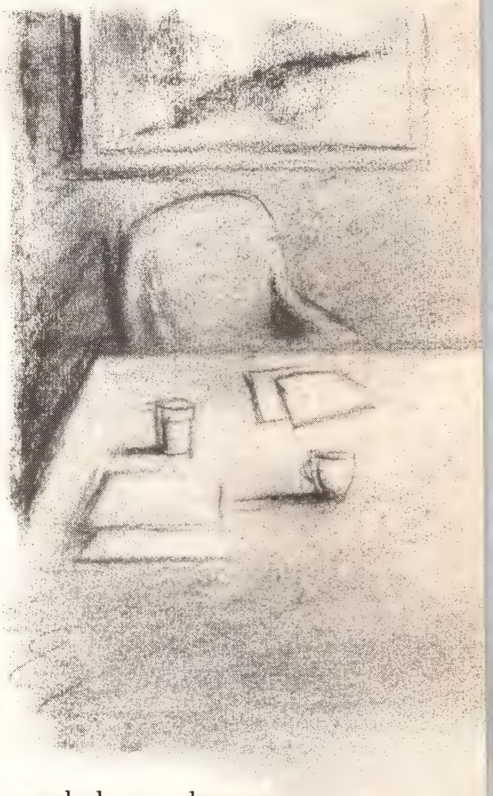

The whistle blower's burden:

Public approval, corporate exile

Deborah Asbrand, *Associate Editor*

In public testimony before the presidential commission investigating the explosion of the space shuttle Challenger, two engineers employed by Morton Thiokol told the panel that they had argued against the launch. Shortly after the men's testimony, the company was reported to have stripped them of their responsibilities, and to have reassigned them to lesser projects.

The men were reinstated following Congressional criticism and an announcement by NASA that it planned to look into the reassignments, but the incident does reveal the serious consequences sometimes suffered by individuals who expose instances of fraud, corporate waste, or safety violations. In recent years, "blowing the whistle" has become more acceptable, but individuals who step forward continue to confront conflicting signals from the public, their employers, and their coworkers—and from all corners, they find little real support.

As a result of the publicity generated by the Challenger tragedy, public pressure on professionals to report corporate or governmental wrongdoings has never been greater, says Professor Myron Peretz Glazer of Smith College. The most telling lesson from the explosion that killed the seven astronauts is the high cost of failures that involve sophisticated technology, says Glazer, co-author of a forthcoming book, *The Courage of Their Convictions: An Ethical Odyssey in Government and Industry*. "If you see specific problems and don't speak up . . . , you're very likely putting a lot of people in jeopardy. That was the fundamental lesson that came across the nation's TV screens."

Some whistle blowers have attained the realm of legend in recent years. Such famed informers as New York policeman Frank Serpico and nuclear worker Karen Silkwood are virtually folk heroes in our society. Louis Clark, executive director of the Government Accountability Project (GAP), an organization that aids informers both inside and outside of government, observes: "It's far more socially acceptable now. Public officials say great things about whistle blowing, there is good TV coverage, you see a showering of acceptance and of awards being given." Professor Glazer argues that the end result of widespread acceptability is that the public expects that those with knowledge of abuses or hazards will report them. "Over the last 20 years, we as a nation have come to expect that in a dangerous situation someone will come forth. We expect that there will always be a Karen Silkwood."

Yet the code of ethics that the workplace honors often contradicts what the public, as well as the individual, conscience dictates. Companies may openly call for frank communication between managers and employees and then privately retaliate against employees who notify their supervisors of misdoings. "Retaliation against whistle blowers is predictable," says Glazer. What he found "astounding" about the Morton Thiokol case was that the engineers had gone before the commission, not of their own volition, but because they had been called to testify, and their employer *still* allegedly retaliated against them.

Internal avenues tried first

Researchers have found that most whistle blowers do act of their own accord in matters involving negligence, initially broaching their concerns with their employer. "They usually go to the supervisor or someone in charge," says Don Soeken, a Maryland psychologist who has studied the cases of more than 80 whistle blowers. "Eighty-five percent say that does no good. The

Paul Schulenburg

majority report retaliation from their supervisor. If they're in private industry, they usually get fired."

Among their coworkers, individuals often find a similar lack of support. In interviews after their testimony, the Morton Thiokol engineers reported that their coworkers considered them disloyal and naive about internal politics—an all too common experience, observers say. "A person in a company who bucks the management, who embarrasses them, often becomes a pariah among fellow workers," says Louis Clark.

Some coworkers fear that if they continue their friendships or even have lunch with an individual who has broken rank with management, management will begin to view them, too, with suspicion, says Clark. In addition, informers often find themselves ostracized by another group: colleagues who also witnessed or had knowledge of the wrongdoing but didn't speak up. "They turn their backs on [the whistle blowers] because of their own shame," says Clark. "They feel guilty and shy away from them."

Clark also points out that, in addition to suffering the usual moral pressure to speak out, engineers find that the scientific nature of their work heaps even more pressure on them. The profession's specific design parameters leave less room for questions—and rationalizations—about a project's quality, he points out; either a product meets design specifications or it doesn't. In addition, signing off on a project or design gives an engineer a sense of personal responsibility, particularly if questions of safety arise. "That is exactly what happened at Morton Thiokol. [When they testified,] the engineers were asked to put on management's hat and approve a decision that, as engineers, they would never have made."

The actions of the Morton Thiokol engineers are typical of the engineers whom Soeken has met through his research. "The [engineering] whistle blowers that I've talked to are traditional ethical thinkers," says Soeken. "They know what's right and what's wrong, and they report it that way. That's part of their training. They think rationally and mathematically."

The process of blowing the whistle, however, remains painfully slow and full of anguish, testing the mettle of even those individuals whose confidence in their decision appears unshakable. Losing support at any stage in the process—whether that support is from the individual's family, friends, or advisors—can threaten the informer's ability to continue.

Lending support

Electrical engineers find little in the way of support from professional societies. Gerald Gordon, chairman of the IEEE Ethics Committee, admits that the organization offers its members no more than moral encouragement. "We don't really know what to do. If we enter these cases, we can be sued too. [Companies] could say that by our entering into the case, they'd lose business. That's one reason we're so timid. Our hands are tied by the threat of suit."

The electrical engineer can turn to GAP, a nonprofit, public-interest organization that offers counseling and legal assistance to those who are employees of government offices or of government contractors, and who are considering reporting wrongdoings. At its headquarters in Washington, DC, GAP's 18 paid staff members, 12 of whom are attorneys, represent clients in more than 80 cases at any given time. Involving 200 clients and more than 300 witnesses, the case load already taxes the staff's capabilities, leaving a limited amount of time to handle incoming calls. Clark regrets that staff members must often schedule a later date at which to talk with callers. "If we never hear from that person again, we're left to think 'if

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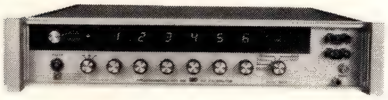

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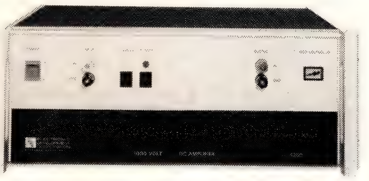
CIRCLE NO 5

1000 Volt AC Amplifier



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Input Voltage: 10 Vac, rms
Fixed Gain: 100
Gain Accuracy: 0.05%
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Dimensions: 7.0H x 19.0W x 13.8D inches
Weight: 40 lbs.
Price: $1995
Availability: 60 days ARO

Engineering Contact: **Bob Ross**
Tel: (617) 268-9696

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TLX: 951596 (ELECDEVCO BSN)
RCA TLX 240 895 (EDC UR)

only we'd been here when they needed us,'" he says. "These people may never talk about it again."

Ten to 12 people telephone GAP each day seeking advice or assistance; 20% to 25% of the calls are from engineers. The shuttle disaster increased the call load dramatically. "Our phones are ringing off the hook," says Ann Lowry, assistant to the director. Of the engineers who phone the center, she reports, nearly all mention the shuttle explosion within the first hour of conversation.

Companies may openly call for frank communication between managers and employees, and then privately retaliate against employees who notify their supervisors of misdoings.

Aware of their pivotal role in the reporting process, GAP's attorneys take pains to allow individuals to make their own decisions about pursuing their complaints. Clark says that although most attorneys advise potential clients not to blow the whistle because of the consequences to their professional and personal lives, GAP's staff takes a different stance. "People are responsible for their own decisions, and lawyers should help them make them most effectively with the least possible harm to themselves," he says. "[An attorney's] job isn't just to see that people should keep their jobs, but to see that people live their lives as they see fit."

Well-developed sense of purpose

A well-developed sense of purpose is often what motivates whistle blowers and gives them the courage to speak out and report what they see. "Our perception is that they have a definition of themselves that goes beyond the work-place definition," says Clark. "They have a sense of themselves that isn't determined by their jobs or their fellow workers, and that allows them to take the risk." It is also what enables them to rebuild their lives after taking a stand against their employer.

Industry's attitude may be changing. Gary Edwards, executive director of the Ethics Resource Center, a Washington, DC, organization that assists companies in developing standards and guidelines for employees, says that corporations' interest in ethical issues normally waxes and wanes according to the public's interest. But the scrutiny that the defense industry's practices have undergone over the past two years, and the corporate-merger trend, which results in companies having to acclimate large numbers of new employees, have resulted in a marked increase in the number of companies contacting the center over an extended period of time.

Corporations face a twofold problem when employees allow fraud, waste, or safety hazards to occur, Edwards points out. Not only is the technical failure itself a problem for the company; management must also overcome the climate of silence that can allow the technical failure to do great harm. "Companies should want an environment where people so identify their values, purposes, and objectives with those of the company that they wouldn't let something go wrong and not tell about it."

Management's responsibilities include shouldering the blame for an environment that fails to support employees, says Edwards. "If they create an environment where good people can't do their jobs and do them with integrity, then they need to be called to task for it." **EDN**

Article Interest Quotient
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High 518 Medium 519 Low 520

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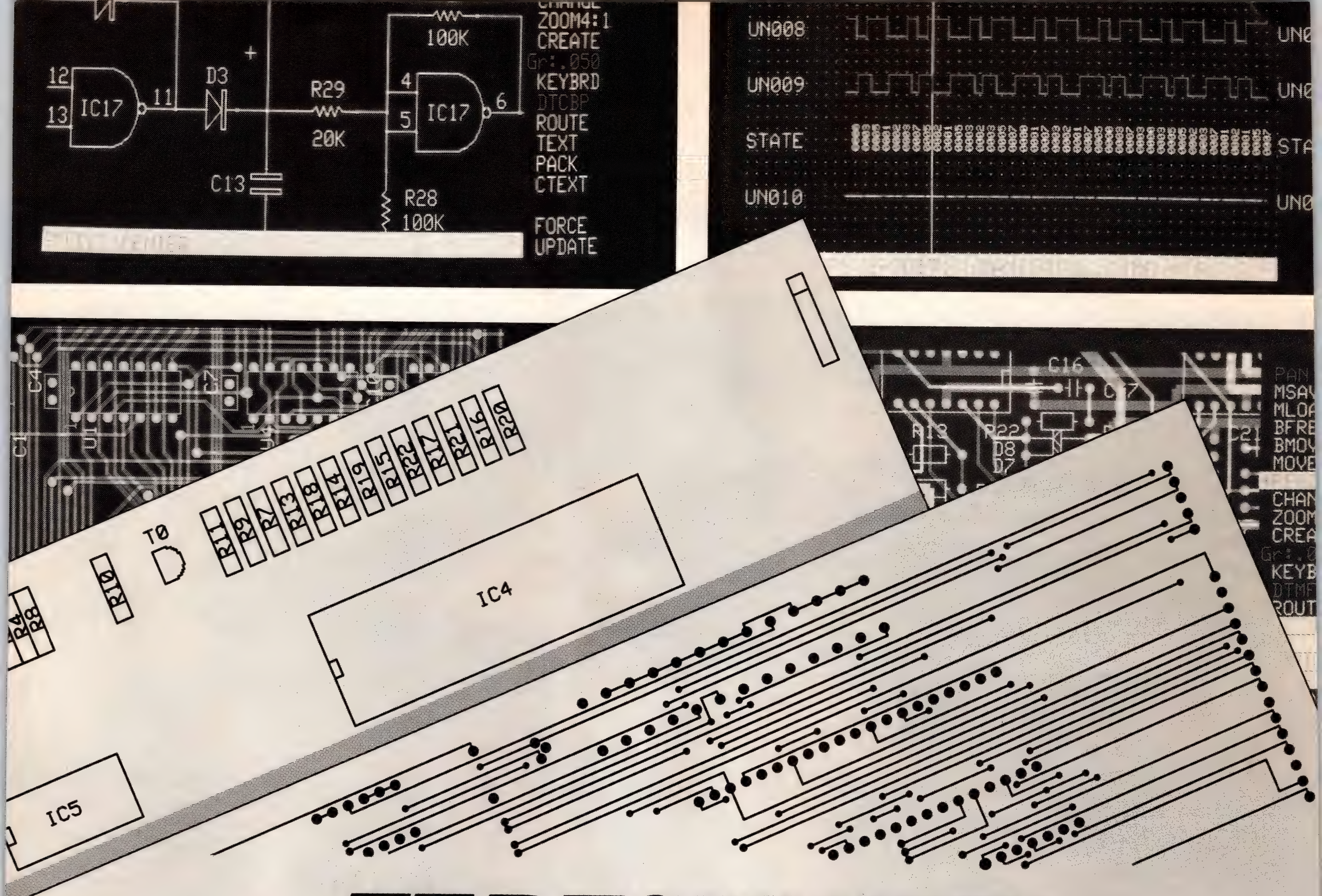

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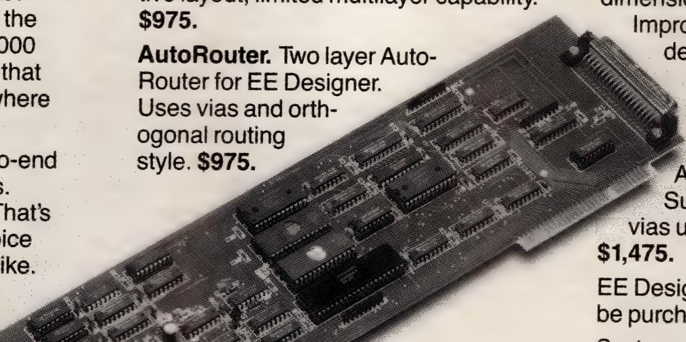

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CIRCLE NO 166

CAREER OPPORTUNITIES

1987 Editorial Calendar and Planning Guide

EDN

Issue Date	Recruitment Deadline	EDN Editorial Emphasis	EDN News
Feb. 5	Jan. 15	Test & Measurment; Communications Technology; Software	
Feb. 19	Jan. 29	Analog ICs; Artificial Intelligence; CAE	Closing: Feb. 4 Mailing: Feb. 20
Mar. 4	Feb. 12	Computer Graphics; Communications ICs; Test & Measurement	Closing: Feb. 18 Mailing: Mar. 16
Mar. 18	Feb. 26	CAE; ASICs; Electro '87; Show & Product Preview	
Mar. 31	Mar. 10	Electro '87 Show Issue; Design & Development Tools; ICs & Semiconductors	Closing: Mar. 19 Mailing: Apr. 9
Apr. 15	Mar. 26	Microprocessor Technology; Software Development; Digital ICs	Closing: Apr. 2 Mailing: Apr. 23
Apr. 30	Apr. 9	Communications Special Issue; ASICs; Test & Measurement	Closing: Apr. 16 Mailing: May 7
May 14	Apr. 23	Analog Technology Special Issue; ICs; Test & Measurement	Closing: Apr. 30 Mailing: May 21
May 28	May 7	Computer Peripherals; Software; Power Sources/Devices	Closing: May 14 Mailing: June 4
June 11	May 21	Math ICs; CAE; Computers	Closing: May 28 Mailing: June 18
June 25	June 4	ASIC (Semicustom ICs) Directory; Analog ICs; Surface-Mount Technology	
July 9	June 18	Product Showcase-Volume 1; ICs & Semiconductors; Software	Closing: June 25 Mailing: July 16
July 23	July 2	Product Showcase-Volume II; Computers & Peripherals; Test & Measurement Instruments	Closing: July 9 Mailing: July 30
Aug. 6	July 16	Computer Boards; Digital Signal Processing; Test & Measurement; Top Ten Reader Vote Contest	Closing: July 23 Mailing: Aug. 13
Aug. 20	July 30	Military Electronics Special Issue; Fiberoptics; Software	Closing: Aug. 6 Mailing: Aug. 27
Sept. 3	Aug. 13	Analog ICs; CAE; ASICs	Closing: Aug. 20 Mailing: Sept. 10
Sept. 17	Aug. 27	Memory Technology; Communications Technology; Software	Closing: Sept. 3 Mailing: Sept. 24
Oct. 1	Sept. 10	Surface-Mount Technology; Computers & Peripherals; Industrial Product Showcase	Closing: Sept. 17 Mailing: Oct. 8
Oct. 15	Sept. 24	Test & Measurement Special Issue; Analog ICs; ASICs	Closing: Oct. 1 Mailing: Oct. 22

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- Monitoring of EW RF, digital, software development process from requirement definition through systems integration and test
- Program/project management and administration

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EATON

Reader Vote No. 9011

ERIM REPORT #4

The Science of Range-Doppler Imaging

Fundamental range-Doppler radar imaging methods developed at ERIM are providing new capabilities in a variety of applications.

Range-Doppler Imaging

Fine Resolution microwave or laser images of objects which are rotating with respect to the radar system can be formed using the principles of range-Doppler imaging. Range resolution for such a system is provided by ranging with wideband waveforms subjected to pulse compression to accurately measure distance to the scatterers of interest. Cross-range, or azimuth, resolution is provided by performing Doppler-frequency spectral analysis (FFT) within range bins. Signals with higher Doppler frequency content are associated with scatterers of greater line-of-sight velocity which in turn implies increasing cross-range offset from object center. Display of the range bins and Doppler-frequency cells within range bins in a rectilinear grid results in a reflectivity image of the rotating object or scene.

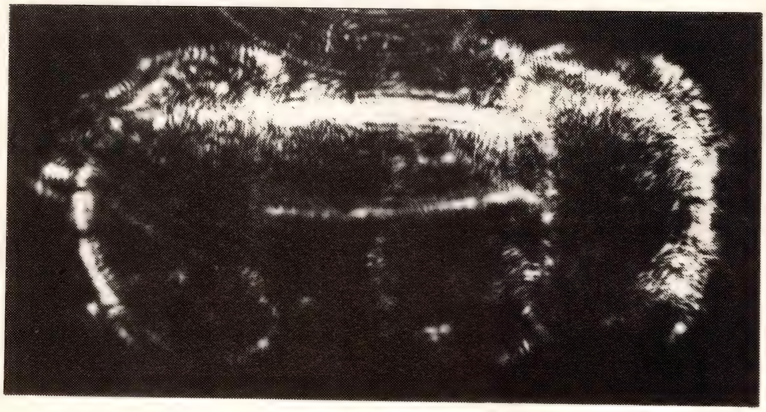
With this approach, finer azimuth resolution is obtained by performing the Doppler spectral analysis over increasing time intervals. However, as one strives for finer resolution the integration time can become so long that individual scatterers begin to move through the image resolution cells that one is attempting to form. In such a case the resultant image quality actually degrades with increased integration time.

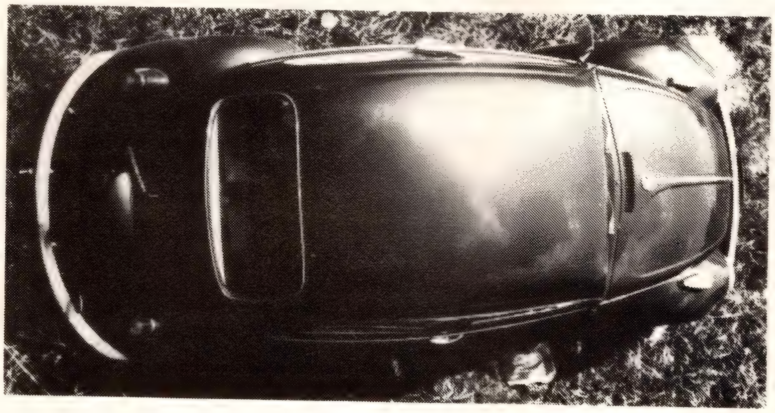
Polar-Format Algorithm

A number of image-formation algorithms have been formulated to compensate for the effects of motion through cells during the integration period. The Polar-Format Algorithm, developed at ERIM for use with our ground-based and airborne imaging radar systems, has become widely noted as an extremely powerful, yet elegantly simple and efficient method for overcoming these previous limits of imaging capability. The images below show a Volkswagon and its associated microwave range-Doppler image processed using the Polar-Format algorithm. This image was produced using the ERIM ground-based, range-Doppler imaging facility.

Applications

Fine-resolution range-Doppler imaging is applicable to a number of situations, including space object imaging (SOI), Inverse Synthetic Aperture Radar (ISAR), and Spotlight-mode SAR for airborne imaging of ground scenes. In principle, the approach is suited to both optical and radar wavelengths, Also, the theory has been extended to allow for three-dimensional imaging of objects given suitable signal collection configurations.





The Environmental Research Institute of Michigan (ERIM) is a scientific research institute that performs contract research services for a variety of sponsors. Our sponsors include government organizations, industry, and universities. Research at ERIM focuses upon remote sensing systems, devices, and techniques that span the electromagnetic spectrum. Within this broad research area, staff members employ their knowledge of modern electronics, optics, computer science, and infrared and microwave physics.

Career Opportunities

ERIM's technical divisions have research and management positions available in Ann Arbor, MI, Washington, DC, and Los Angeles, CA. Positions are available at several levels in the following areas:

- **Radar System Engineering and Analysis**
- **Signal and Image Processing**
- **Microwave Scattering and Measurement Engineering**
- **Diffractive Optics**
- **E-O/IR System Design and Analysis**
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ERIM REPORT #3

The Science of Radar Image Processing

ERIM researchers are investigating numerous topics in the field of radar image processing, including speckle reduction and synthetic image generation.

Speckle Reduction

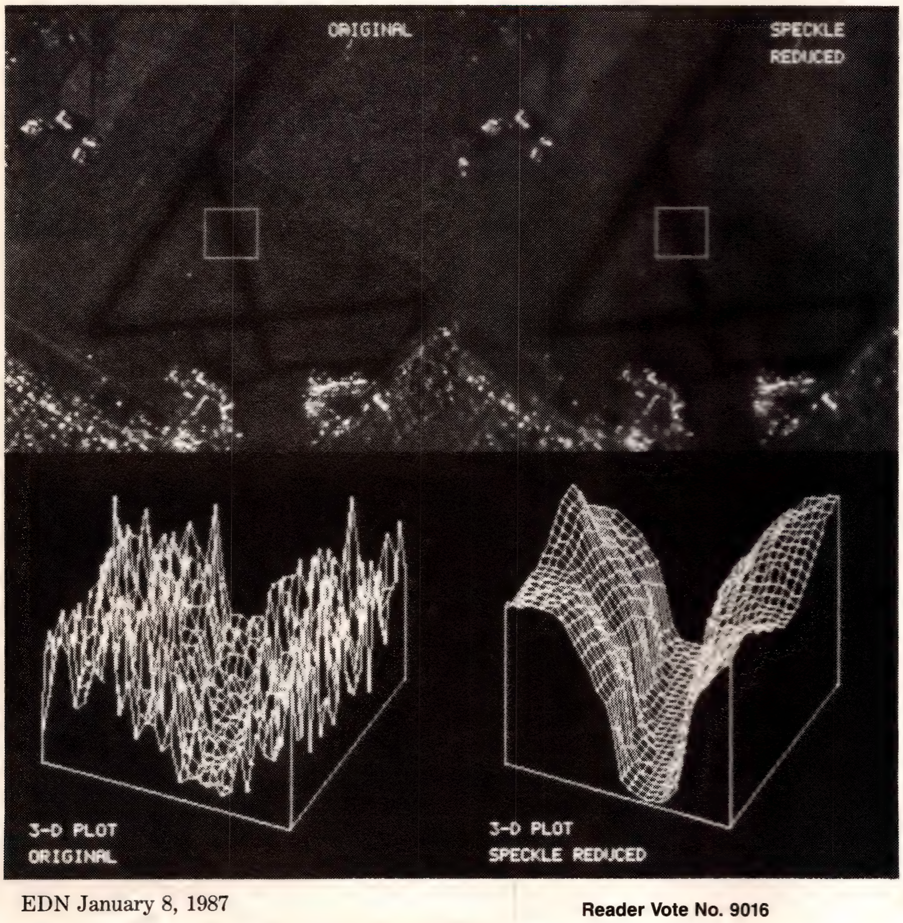
Due to the coherent nature of the synthetic aperture radar imaging process, radar images suffer from a disturbing speckle noise. This "salt-and-pepper" appearance of the imagery is a hindrance to the performance of radar image interpreters as well as automatic recognition algorithms. Conventional speckle reduction techniques, such as noncoherent integration of multiple looks and median filtering, degrade image resolution and thereby blur key image features such as edges and point returns.

To overcome this difficulty, ERIM researchers developed a nonlinear speckle reduction algorithm based on geometric concepts. The method iteratively applies a sequence of neighborhood processing operations based on the "digital convex hull". As shown below, this algorithm preserves edges and strong returns in the image without resolution degradation while smoothing speckle.

Synthetic Image Generation

The ability to synthetically generate radar images of modelled objects has many important advantages. These include imaging of objects which do not physically exist, interactive object design via changing of object material properties or shape, and avoidance of costly sensor collections.

ERIM's staff have developed a hardware/software system capable of producing realistic radar images of modelled objects. A combinatorial solid geometry model of the object is first generated from available plans and photos. This model is then input to a module which emulates the electromagnetic interaction between radar and object. Important features such as multiple reflections, shadows, range layover and added noise are faithfully portrayed in the resulting imagery. Extension of this capability to include IR and optical wavelengths is now underway.



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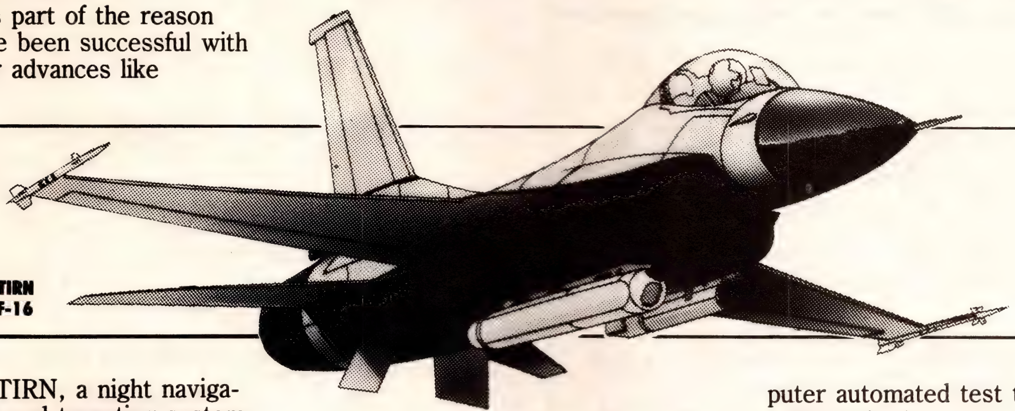

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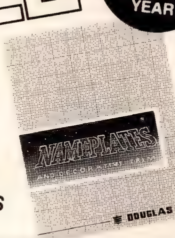

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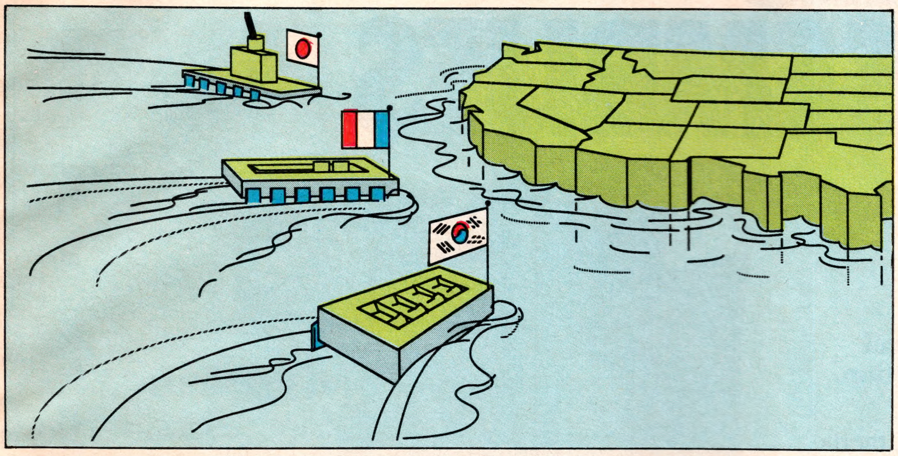
LOOKING AHEAD

EDITED BY GEORGE STUBBS



Electromechanical-switch market draws foreign entries

With their eyes on a projected $1.5 billion market by 1991, foreign manufacturers of electromechanical switches are expected to provide more devices to US customers, according to the market-research company Venture Development Corp (Natick, MA). Right now, only 7.6% of the switches sold in the US are imported, a total that closely matches the level of US switch exports. The 1985 US market for electromechanical switches was worth $1.1 billion; a 5% annual growth rate is thus expected.

The threat of foreign competition varies according to the market segment, in a pattern that's familiar to other US industries. US manufacturers of high-volume, low-cost switches face a very real and very serious threat, says VDC. Producers of such products as thumbwheel or rocker switches, which are regarded as "less standard" products, have less to fear. Still, says VDC, the direct and indirect impacts of foreign competition will increasingly affect US switch makers.

Both European and Asian companies are supplying, or planning to supply, electromechanical switches to the US market. Some of these companies are already well established in the US; many others are start-up companies entering the US market for the first time. These companies are typically quite aggressive, says VDC. Presuming the US dollar stays strong on foreign markets, foreign companies can be expected to gain a share of the electromechanical-switch market at the expense of domestic switch manufacturers.

The upshot of this news, says VDC, is that US switch makers can no longer form comprehensive, competitive strategies without considering the global electromechanical-switch market. A successful global strategy rests on the ability to reduce the cost of production, to gain the appropriate international approvals, and to revise product lines for international appeal, among other things. As in other industries, one possible outcome—with mixed consequences for the US economy and US citizens—is the movement of production facilities to offshore locations.

Fiber-optic communication threatens switch market

Any purchaser of equipment for a communications network must balance the cost of the components that carry voice, text, and data information—the transmission facilities—with the cost of the switching systems that direct the information. In recent years, information-switching equipment has become very sophisticated—and expensive. Switches, however, have remained a sound economic alternative to establishing direct, point-to-point connections between facilities that need to communicate with one another in a network, whether in a business network or in the public sector. Now, the economics of this tradeoff have been "radically altered by the arrival of fiber optics," says International Resource Development Inc, a market-research company based in Norwalk, CT.

The chief virtue of fiber-optic transmission is its ability to carry high volumes of information at high speeds. It even promises to make the transmission of pictorial information fast, easy, and inexpensive. "Nothing else will be able to touch fiber optics for cheap wideband transmission," says IRD researcher Lawrence D Gasman. This abundance of capacity, Gasman predicts, will eventually lead to a reduction in the cost of point-to-point transmission, so that a network may no longer need a switch in some locations where a switch once served.

IRD predicts an era of more centralized switching and a move away from the present, complex switching hierarchy of local and regional switching centers. As a consequence, backhauling—the switching of circuits over "apparently geographically irrational" routes—will become more common as the use of switches decreases.

IRD reports, however, that the familiar bureaucratic crawl of regulatory authorities could slow down the rate at which carriers move toward networks based on fewer switches. Making the necessary changes in equipment for this move requires higher depreciation rates, which increase telephone rates, at least temporarily. Because regulatory agencies are under pressure not to pass on rate increases to the public, they are not inclined to act quickly.

Making the Connection Between...

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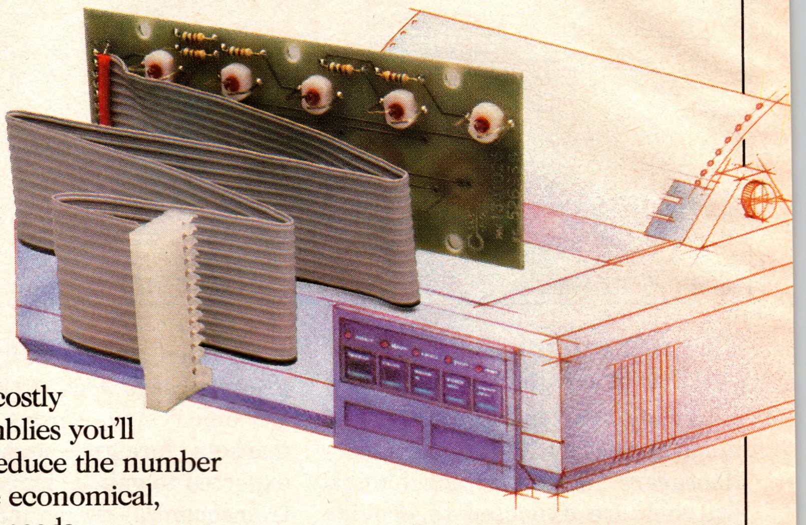

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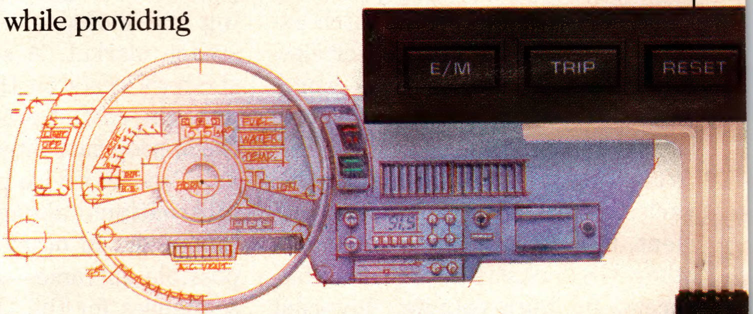

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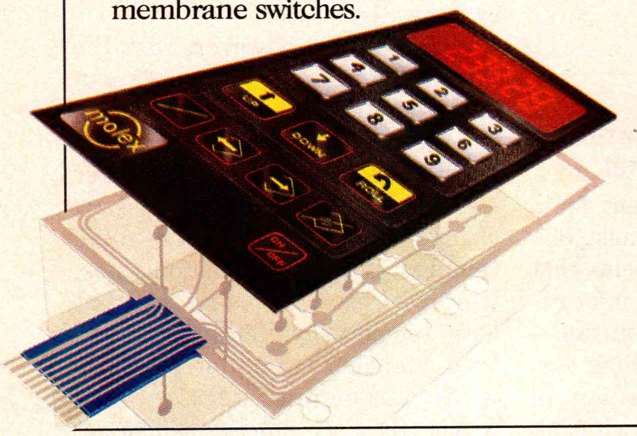

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